UNDERSTANDING MP3 AUDIO COMPRESSION • PUT USB IN YOUR PROJECTS

Nuts & Volts

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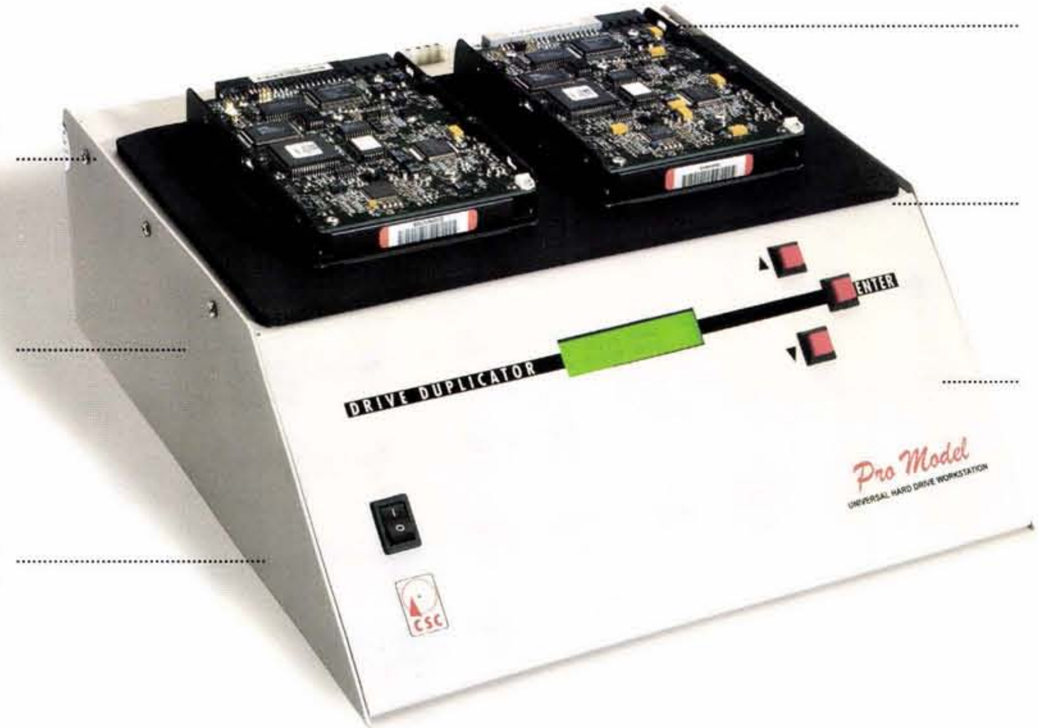

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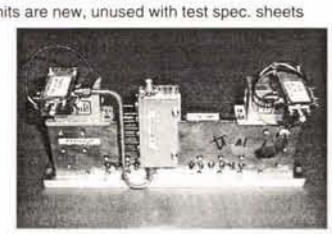

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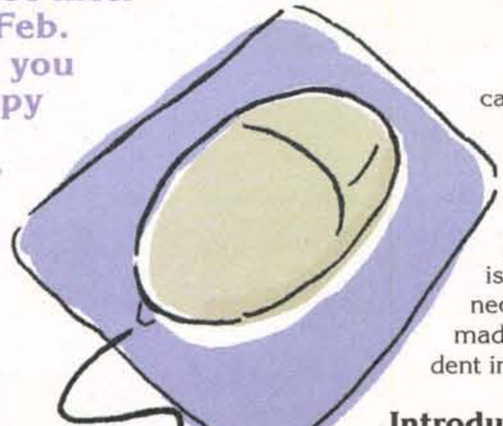
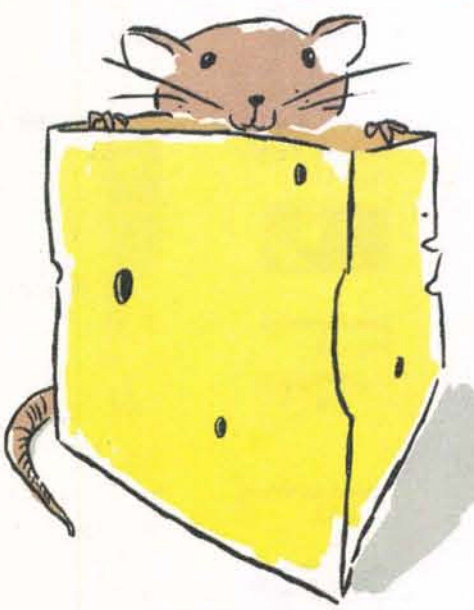
by Steve Parkis

BUILDING A BETTER MOUSE TRAP — PART 3

A Keyboard for Your Stamp

If you built the BASIC Stamp mouse interface in the Feb. 2000 issue, you may be happy to know that you're just a few minutes of programming time away from a full-featured, PS/2 keyboard capability for your Stamp. If you passed up last month's project, perhaps this final article will entice you to take the plunge. This final installment presents a one-chip, Scenix SX28 microcontroller-based keyboard interface using only two Stamp I/O pins. The interface provides an HD44780-compatible LCD interface in the bargain. This article describes fundamental keyboard functions, presents the SX28 interface program, and illustrates its use with some BASIC Stamp code snippets.





System Architecture

The PS/2 mouse and keyboard were designed for a personal computer's fast, interrupt-driven processing and lots of on-board controller and buffer capabilities. The BASIC Stamp is an ingenious piece of work, but it lacks some of these features. As a result, using a Stamp effectively often depends on finding ways to pace external devices to prevent losing or being overrun by data. Last month, we used the mouse's "on demand only" (remote mode) feature to effectively control the input stream. For the keyboard, we will use the keyboard's own buffer and some interface tricks for the same purpose.

The keyboard interface accepts Stamp-originated commands destined for the keyboard, forwards them on, and passes back relevant command response information. It also accepts raw keystroke data, converts it (in most cases) to ASCII, and passes that information to the Stamp upon demand. The Stamp's program need not "stare at" the keyboard to avoid missing data, and it can use the ASCII data directly in text-related processes.

The wiring diagram, Figure 1, is the same as last month's mouse interface except the "Mouse connector" is now labeled "Keyboard connector." The only changes to be made involve the programs resident in the interface and the Stamp.

Introduction to PS/2 Keyboard

For purposes of this article, a PS/2 keyboard is a keyboard that plugs into a PS/2 (six-pin mini DIN) connector. That includes keyboards provided with PCs for the last several years. There are many PS/2 keyboard variations corresponding to the distinct PC generations; all will work with this interface. The keyboard uses the same connector pinout, logic levels, and synchronous serial communication protocol as the mouse (see the Jan. 2000 issue for all the logic and timing issue details).

The command set is reminiscent of the mouse, but the keyboard's output data stream is more complex and variable. These keyboards are sophisticated devices with lots of internal processing capability. A selected set of keyboard functions and properties are described so the interface can be used effectively for your Stamp project.

One example of the keyboard's built-in "smarts" is its ability to use any of three distinct transmission formats, or scan code sets, to report keyboard activity. Each scan code set may represent a key closure (make) or release (break) by sending one or more data bytes uniquely identifying the key pressed or released. The scan codes bear no resemblance to the ASCII codes we normally associate with keyboard characters.

Scan code sets 1 and 2 send make and break code sequences for essentially all keys. The sequences can get ungainly — as many as eight bytes for a single key "make." A PC's keyboard typically operates using scan code set 2, which offers the most complicated scan code sequences. Fortunately, scan code set 3 is relatively simple and has very few multi-byte sequences — just the ticket for a roll-your-own interface controller.

This project's interface assumes scan code set 3 is in use for its conversion of scan codes to ASCII codes, but you can command the keyboard to alternate scan code sets if desired (see the See for Yourself section later).

The keyboard's special-purpose keys (Shift, Caps Lock, Alt, Ctrl, Win) deserve some special attention. First, it's important to appreciate that all scan codes remain the same whether any of the special-purpose keys are active or not (at least for scan code set 3, which is assumed here). For instance, the keyboard generates scan code $1c if the 'A' key is pressed regardless of the states of Caps Lock, Shift, Alt, Ctrl, or Win. External logic must interpret the scan code in light of the special-purpose key states.

Second, your keyboard almost certainly has three LEDs up on the right side (Num Lock, Caps Lock, Scroll Lock). Pressing the Caps Lock/Num Lock/Scroll Lock key does not cause the keyboard to automatically turn the corresponding lock LED on. Again, logic external to the keyboard must note that a locking key has been pressed and send a command to turn the appropriate LED on or off depending on its previous state.

The interface program handles these special-purpose key considerations so your Stamp program can worry about other things. It converts scan codes to the appropriate ASCII codes after considering the whole picture:

Additional Reference Material

For more, in-depth information on keyboard functions, the following are recommended. *IBM, Technical Reference Manual for XT, AT, PS/2.* Messmer, Hans-Peter, *The Indispensable PC Hardware Book,* Addison-Wesley, 1997. Soffel, Volker, National Semiconductor Application Note 734, MF2 Compatible Keyboard with COP8 Microcontrollers, 1991 (a great resource: http://www2.national.com/an/AN/AN-734.pdf)

which key was pressed, the states of Caps Lock, Num Lock, and either shift key. It also automatically sets the locking indicator LEDs as appropriate. As a result, the Stamp can deal with preprocessed ASCII data that reflects the entire state of the keyboard.

ASCII Code Conversion

As described above, the interface program converts scan codes to ASCII codes that the Stamp can use directly. In reality, this includes "real" ASCII and some "pseudoASCII" codes since, for example, there is no ASCII code corresponding to "Insert," "F1," or many other keys on the keyboard. Standard ASCII codes are sent for all letters, numbers, punctuation marks, the Esc, Tab, Backspace, Delete, and Enter keys. These are sent as the appropriate upper/lower case codes ('a' versus 'A', '1' versus '!', '6' versus "right arrow" on the numeric keypad) reflecting the current Caps Lock/Num Lock and/or Shift states.

PseudoASCII codes are sent for the function keys, cursor manipulation keys, and special-purpose keys. No universally-accepted standard exists for ASCII equivalents to these keys, so the pseudoASCII codes used here were selected and assigned for efficient analysis on the receiving end: the Stamp application program.

Table 1 shows the pseudoASCII codes sent for these keys. Their code set 3 make codes are also shown for information only. Keys prefixed with '#' appear on the numeric keypad. Note that duplicated keys such as Home and #Home are assigned the same pseudoASCII code.

Data from the Interface

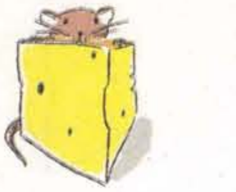
Most of the time, your Stamp program can use the interface's ASCII codes without further interpretation. However, your application may need to treat ^s (Ctrl plus 's') much differently than a plain 's.' You could keep track of the status of each special-purpose key within your Stamp program to do this, but the interface program offers a handier alternative.

Each ASCII/pseudoASCII code generated by the interface is preceded by a "preamble" byte of status information. The preamble byte bits have the following meanings:

Bit0: 1 = Scroll Lock in effect
Bit1: 1 = Num Lock in effect
Bit2: 1 = Caps Lock in effect
Bit3: 1 = Left or Right Shift key currently depressed
Bit4: 1 = Left or Right Alt key currently

Command Code	Function	Required Parameters	Response from SX
$00	SX echo	1 echo byte	1 byte echoed
$01	Keyboard reset	none	1 byte: $AA if self-test OK
$02	Send data to LCD	1 byte for display	none
$03	Send command to LCD	1 byte: LCD command	none
$04	ID keyboard	none	2 bytes: keyboard ID word
$05	Set LEDs	1 byte: LED values	none
$06	Check scan code set	none	1 byte: scan code set
$07	Select scan code set	1 byte: code set # none	
$08	Set to standard, disabled	none	none
$09	Set to standard, enabled	none	none
$0a	Enable keyboard	none	none
$0b	Send keyboard echo	none	1 byte: $ee
$0c	Send keystroke data	none	2 bytes: preamble + data
$0d	Set rates	1 byte: rate data	none
$oe	Read LCD cursor char	none	1 byte: character at cursor
$of	Set LCD cursor position	1 byte: new address	none
$10	Report LCD cursor position	none	1 byte: LCD cursor address
$11	Send all available	none	2 bytes: preamble + data, keyboard data (scan codes) repeated until buffer empty

TABLE 2



depressed
Bit5: 1 = Left or Right Ctrl key currently depressed
Bit6: 1 = Left or Right Win key currently depressed
Bit7: 1 = Valid ASCII/pseudoASCII data in following byte

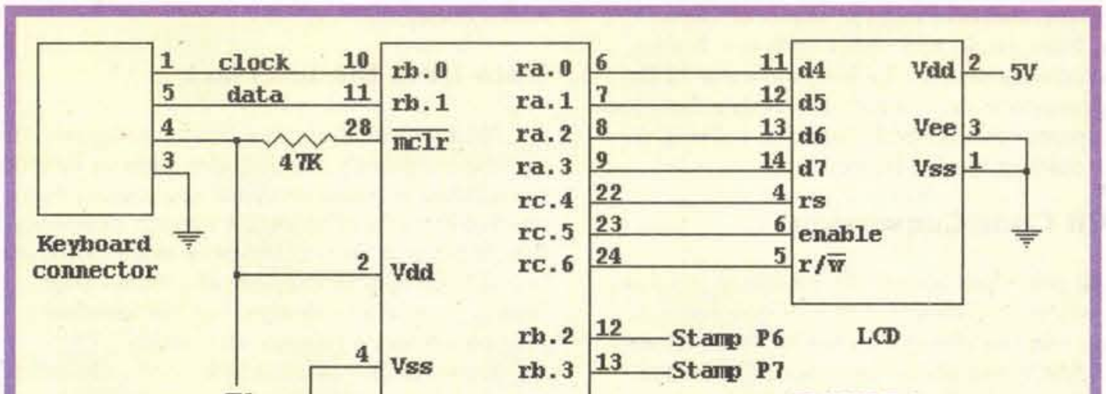


FIGURE 1.
WIRING DIAGRAM

As an example, assume an initial condition where Caps Lock is not in effect. If the Caps Lock key is then pressed, the interface program will automatically command the keyboard to illuminate the Caps Lock LED, send the Stamp a preamble byte with bit 2 set, followed by the pseudoASCII code $93 (hexadecimal 93), representing the Shift Lock key itself. If the 'S' key is then pressed, the preamble byte will still indicate that Caps Lock is in effect, and the follow-on byte will contain $53, the ASCII code for (upper case) 'S.'

The preamble byte indicates why an upper case ASCII code was received, which may or may not be useful to your Stamp program. The next time the Caps Lock key is pressed, the interface extinguishes the LED, resumes sending preamble bytes with bit 2 cleared, and sends another $93.

Now consider the left Ctrl key with the same initial conditions. Pressing the left Crtl key generates a preamble byte with bit 5 set followed by pseudoASCII code $92. If the 'S' key is then pressed before releasing left Ctrl, a preamble byte with bit 5 set and the ASCII code $73 ('s') are sent, identifying the keystroke as ^s. Subsequently releasing the Ctrl key does not generate output from the interface; it simply causes bit 5 to be reset (0) in succeeding preamble bytes. In fact, no break codes are ever forwarded to the Stamp; their effects are reflected in the preamble byte (excluding "See for Yourself" mode, below).

Using keyboard scan code set 3 presents a small difficulty with the right Alt/Ctrl keys. Make codes tell the interface when these keys are pressed, but there are no set 3 break codes issued for these two keys and hence no way to know when either key is released. The interface program handles this by essentially treating these two keys as "Alt Lock" and "Ctrl Lock" — each press toggles bit 4 or bit 5 in the preamble byte. This does not apply to the left Alt or Ctrl keys, which do have set 3 break codes and perform in the expected momentary fashion.

The preamble byte's bit 7 merits further explanation. After the Stamp prompts the interface to return keystroke information, its program may typically enter a wait until the interface responds. While the Stamp is waiting, the interface checks the keyboard for any pending keystroke data. In the event the keyboard's buffer is empty, the interface promptly

Stamp Program #1:

```
' KEYBRDP1.BS2
' Keyboard demonstration program to show control of lock
' indicator LEDs.

X               VAR   BYTE                  ' utility byte variable
to_SX           VAR   BYTE                  ' data to SX keyboard interface
from_SX         VAR   BYTE                  ' data from SX keyboard interface
keyboard_bits   VAR   BYTE                  ' keystroke status data
valid_data      VAR   keyboard_bits.BIT7
keyboard_data   VAR   BYTE                  ' keystroke ASCII/pseudoASCII data

awaitSX:
' Wait for SX interface to assert low on clock line as part of its
' initialization. At that point it's safe to attempt command
' transmissions.
FOR x = 0 TO 255:IF IN6 = 1 THEN awaitSX: NEXT

to_SX = 7: GOSUB putSX              ' use scan code set..
to_SX = 3: GOSUB putSX              ' ..3

main:
FOR x = 0 TO 7
to_SX = 5: GOSUB putSX              ' set lock indicators to..
to_SX = x: GOSUB putSX              ' ..x
PAUSE 500
NEXT
x = 7

flashLEDs:
to_SX = 5: GOSUB putSX              ' set lock indicators to..
x = x ^ 7: to_SX = x: GOSUB putSX   ' ..opposite states
PAUSE 200
GOTO flashLEDs

' use the following subroutines for other snippets, too

putSX:
' send byte to SX interface
IF IN6=0 THEN putSX                 ' wait for SX to release clock line
SHIFTOUT 7,6,0,[to_SX]              ' shift to_SX byte out
INPUT 6                             ' restore clock line to input
INPUT 7                             ' restore data line to input
RETURN

getSX:
' accept byte from SX interface
IF IN6 = 0 THEN getSX               ' wait for SX to release clock line
SHIFTIN 7,6,LSBPOST,[from_SX]       ' shift from_SX byte in
INPUT 6                             ' restore clock line to input
RETURN
```

Stamp Snippet #1:

```
main:
to_SX = 12: GOSUB putSX                    ' prompt interface for keystroke data
GOSUB getSX: keyboard_bits = from_SX       ' load preamble status info
GOSUB getSX: keyboard_data = from_SX       ' load ASCII/pseudoASCII data
IF valid_data = 0 THEN main                ' if keyboard tapped out go back
to_SX = 2: GOSUB putSX                     ' send ASCII data to LCD
to_SX = keyboard_data: GOSUB putSX
GOTO main                                  ' go back for more
```

Pseudo -ASCII code	Key	Scan code	Pseudo -ASCII code	Key	Scan code
$81	F1	7	$97	insert	67
$82	F2	F	$97	# ins	70
$83	F3	17	$98	# home	6C
$84	F4	1F	$98	home	6E
$85	F5	27	$99	page up	6F
$86	F6	2F	$99	# page up	7D
$87	F7	37	$9	bend	65
$88	F8	3F	$9b	# end	69
$89	F9	47	$9c	page down	6D
$8a	F10	4F	$9c	# page down	7A
$8b	F11	56	$9d	up arrow	63
$8c	F12	5E	$9d	# up arrow	75
$8d	prt screen	57	$9e	left arrow	61
$8e	scroll lock	5F	$9e	# left arrow	6B
$8f	pause	62	$9f	down arrow	60
$90	left alt	19	$9f	# down arrow	72
$91	left shift	12	$a0	# right arrow	74
$92	left ctl	11	$a0	right arrow	6A
$93	caps lock	14	$a1	# num lock	76
$94	right shift	59	$a2	left win	8b
$95	right alt	39	$a3	right win	8c
$96	right ctl	58	$a4	context menu	8d

Table 1. PseudoASCII Codes

returns a preamble byte with bit 7 cleared (0) followed by a null ASCII byte ($00) to indicate that no keyboard data is available. This gives the Stamp program an efficient "IF key pressed THEN...ELSE..." logical capability.

In summary, the preamble + ASCII/pseudoASCII scheme means the Stamp needn't keep track of key releases, special-function key states, or idly await input.

A Scan Code Spigot

Effectively controlling the keyboard's output stream is a critical aspect for the interface program. If enabled and keys have been pressed, the keyboard doesn't wait to be asked for scan codes (there is no mouse-like remote mode), it just starts sending them — or tries to, anyway. Recall that the mouse/keyboard synchronous serial protocol requires that the clock line be high before transmissions are initiated. The interface program uses this to advantage by holding clock low unless and until directed by the Stamp to retrieve keystroke information or to send a command to the keyboard. Between bursts of transmission, the keyboard's 16-byte FIFO buffer accumulates scan code data. As long as the Stamp program checks for keystrokes often enough to prevent the buffer from overflowing, no keystrokes are lost while the Stamp is taking care of other business. See the getKeyboardByte subroutine in KEYBOARD.SRC for the implementation details. You can download this program from the *Nuts & Volts* website at www.nutsvolts.com.

The Keyboard as an Output Device

Consider those three LEDs up there in the corner. For the right application, they may be all that's needed for output indications. They can represent a number from 0 to 7, or could represent three on/off conditions totally unrelated to the keyboard itself. The interface supports Stamp commands to turn the LEDs on/off as desired. For example, Stamp Program #1 will cycle the LEDs through all possible combinations, then flash all three simultaneously (just try to ignore the latter as a prompt for operator action!).

Note that setting the locked indicator LEDs in this fashion has the same effect on keystroke data reported to the Stamp as does pressing the respective locking keys. This allows your Stamp program to perform a virtual press of the Caps Lock key, for example. If you want to use an LED indicator without affecting how the ASCII/pseudoASCII data are reported, limit this activity to the Scroll Lock LED, or restore the prior LED states when the output procedure has completed.

Be sure your Stamp program uses a one-byte-at-a-time I/O scheme like that shown in Program #1. The interface program needs the Stamp clock and data lines to be idle (i.e., INPUT on the Stamp) after each byte to perform its overall "traffic cop" Stamp-keyboard communications control. Attempts to send/receive multiple bytes with one SHIFTIN/SHIFTOUT instruction will cause communication collisions, gridlock, or other traffic problems.

Stamp Snippet #2:

```
main:
to_SX = 17: GOSUB putSX               ' send see for yourself command
GOSUB getSX: keyboard_bits = from_SX  ' get preamble byte
GOSUB getSX: keyboard_data = from_SX  ' get scan code byte
IF valid_data = 0 THEN main           ' go back if keyboard empty
DEBUG CR

showCodes:
DEBUG HEX2 keyboard_data," "          ' show scan code byte
GOSUB getSX: keyboard_bits = from_SX  ' get next preamble byte
GOSUB getSX: keyboard_data = from_SX  ' get next scan code byte
IF valid_data THEN showCodes          ' show it unless sequence depleted
GOTO main                             ' go back for next key
```

Keystrokes to LCD Example

Replace the "main" routine in Stamp Program #1 with Stamp Snippet #1 to display keystrokes on the LCD.

This will simply throw typed characters at the next available LCD position, which eventually won't look good. The interface program's LCD cursor control functions are available to implement Backspace, Tab, or Enter key text positioning functions from your Stamp program (see February's BASIC Stamp cursor shifting routines in support of the mouse for some techniques).

See for Yourself

Being a *Nuts & Volts* reader, you may feel the need to see the keyboard scan code data "as-is" rather than messaged into preamble + ASCII form. Substitute Stamp Snippet #2 for "main" in Stamp Program #1 and press any key (on the keyboard connected to the interface). Scan code data will appear on your Debug screen. Preamble bytes precede scan codes in this mode as well, but only the valid_data bit has significance. Try changing the scan code set to 2 and then press the interface keyboard's Pause key for a prime example of why set 3 was selected for this interface program.

The SX Interface Program

The SX28 program, KEYBOARD.SRC, modifies last month's mouse interface to use keyboard-specific commands, adds the clock "gating" control logic to the keyboard I/O routines, and implements scan code-to-ASCII code lookup tables in page 3. The lower case or upper case version of the lookup table is used as warranted by the states of Caps Lock/Num Lock and Shift. The ASCII code conversion for the few scan codes greater than $7f is hard coded, while all other keys are translated using the ASCII lookup tables.

Table 2 summarizes the keyboard interface's command set. Send these commands from your Stamp program and the interface will take it from there. Refer to the interface program's source code for details of the command functions and parameter bytes' required formats.

Component Suppliers

B G Micro's 4x20 LCD1002 ($5.95, **www.bgmicro.com**) is an economical and effective LCD choice. **Parallax, Inc.** (**www. parallaxinc.com**) sells the BASIC Stamp II and the SX28AC/DP microprocessor.

Parallax also sells hardware programmers for the SX series, and offers an excellent, free SXKey28L assembler, which can be downloaded from the Parallax web site.

New PS/2 keyboards (and mice) are usually available for $10.00 or less from the **Computer Surplus Outlet** in Las Vegas, NV (**www. computersurplus outlet.com**). **NV**

reader FeedBack

Dear Nuts & Volts:

I have read your "Closed Captions, V-Chip, and other VBI Data" article in January 2000 *Nuts & Volts*, and am disappointed that more information on the structure of the vertical blanking interval data was not provided.

A closed caption decoder could probably be built using a National LM1881 sync separator, an appropriately programmed PIC, and an alphanumeric display module.

Those of you who have an old eight-bit assembly language programmable computer gathering dust (I have a Rockwell AIM-65), could hook the LM1881 to its parallel user port and put it to some use again.

VBI data can't be that complex that an over $100.00 document is needed to explain it. I look forward to reading more on video VBI data in future issues of *Nuts & Volts*.

Michael Kiley
Crestwood, IL

Letter from reader Dave Bunting to Evert Fruitman.

I enjoyed your article "Automatic Night LED," you write in language I can understand. Thank you! I decided to build your LED reading light and in the process discovered some facts about light source efficiencies that you'd find interesting if you don't already know.

I decided to use a solar-charged 12V (sealed 2 x 3 x 1" 1.2 AHr) battery which I'm setting up. On 12 volts, I decided to use three series of three each, total nine LEDs. I decided to try to run them at triple their rated current, but at only 25% duty cycle, using the flip-flop circuit in your article increased to 400Hz. (As I understand triple current at 25% duty appears much brighter to our vision system than just rated current on 100% duty cycle, and that most LEDs can be operated this way.)

On looking at sources, I ordered 10 of the new 7,000 µcd white LEDs from Hosfelt for $5.99 each. Then the surprising learning part started.

I told my brother — an electronics engineer — about this. He was not very encouraging, saying that LEDs are not efficient light sources, that I'd do a lot better with, for example, simply a fluorescent camping lantern. I was surprised, as I'd always thought LEDs were nearly 100% efficient. But on calculating the candles per watt for light sources from values given in catalogs, I learned the following surprising facts.

The units are abominable, most of these light sources are rated in — and so I use — µcd (microcandles, millionths of candles). For comparison, a flat-wick kerosene lantern produces about five candles, about 5 million microcandles.

LEDs produce around 5,000 µcd/watt for the old "regular," typically, 5 µcd LEDs to 20,000 µcd/watt for the 2,000 µcd LED you used in the article, to 200,000 µcd/watt for the newest highest power like 18,000-36,000 µcd orange LEDs.

Incandescent bulbs (I was looking at flashlight-type bulbs) are much better, producing about 500,000 µcd/watt.

Fluorescent lamps (using the 3mm dia. tubes in All Electronics catalog, combined with data from the manufacturer JKL's web site) produce light way up in the range of 2 to 8 million µcd/watt. And these new fluorescents use tiny switching power supply inverters of high efficiency, not like the old low-efficiency heavy ballasts. (Though my efficiency doesn't include losses in the inverters; I'm waiting for my order from All Electronics so I can test the efficiency of these. Their 3mm x 100mm tube produces 2.6 million µcd and their 3mm x 150mm tube produces 4.2 million µcd, about equal to a flat-wick kerosene lantern.)

So fluorescents produce typically 30 times more light per watt than the very best new LEDs, and 1,000 times more than the old "regular" LEDs.

Just this morning, I tested a ($5.00 from MCM) "LightStick-type" 12VDC 12-inch fluorescent work light made to plug into a cigarette lighter. Although it's labeled and advertised as having an 8-watt tube, surprisingly it draws only 170 mA at 12.25 volts, or 2.1 watts, and produces plenty of light, calculated to be something like 10 million µcd (or 10 candles, double a kerosene lantern), reasonably nice light by which to read. (Though for reading, it would benefit a lot by having a much better reflector to focus the light into a narrower beam than its 180+ degree spread.)

Its producing calculated 10 million µcd at cost of 2 watts, as compared to your LED setup which with two LEDs in series would produce 4,000 µcd, which is 1/2500th as much light, at cost of 0.2 watt, a tenth as much power.

You were aiming for a usable albeit minimum reading light at the ultimate lowest power consumption of 0.2 watt and these fluorescents all consume a lot more than that, so they wouldn't serve that lowest-power need of your camper friend as well as your design would serve him.

The lowest-power high-efficiency light source I see is the 3mm x 100mm fluorescent at 2.6 million µcd (2.6 candles, half a kerosene lamp, 650 times your LED setup) at cost of 1.1 watt (5.5 times your setup).

I just thought you'd be interested. And certainly don't take this as any sort of criticism of your article, I appreciated your article very much! Write more, I'll watch for them.

Dave Bunting, Packwood, WA

Response:

David, thank you for your kind note. It always makes me feel good to think that someone enjoyed an article. Glad to hear that you could even understand what I wrote.

First, let me say that it looks like you did a lot of homework, research. The other light sources that you listed seem to give more light per watt than LEDs.

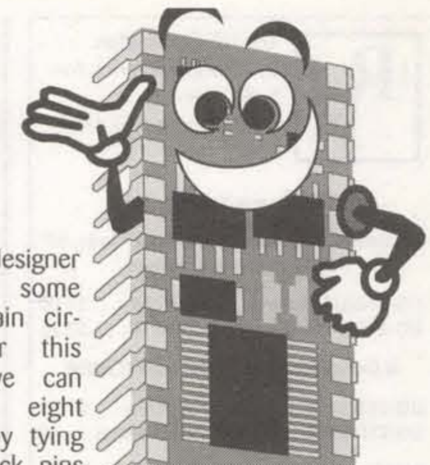
However, I was looking at a relatively simple, portable light source that would give long battery life. My camping friend took a pair of the constant current reading lights, Figure __B (I think 4B) and made a head band for the bare-bones unit.

He said that they gave enough light for everything that he did in

Continued on page 26

STAMP APPLICATIONS

by Lon Glazner



Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

A Digital-to-Analog Converter for All Seasons

The digital-to-analog converter (DAC) is relatively common in embedded control designs today. Many circuits respond best to analog inputs, which leads to a requirement for digital front ends. These digital front ends then interface to various controlling entities, or sensors, or both.

Overview

The BASIC Stamp is an ideal device for controlling a DAC. These DAC and BASIC Stamp working in conjunction, and connected to other simple circuitry, can meet a large variety of analog interface requirements.

I'll cover a powerful and simple circuit that is flexible enough for a myriad of designs which might require analog control signals.

Defining the Design

So I'm sitting behind the desk one day, playing Lunar Lander on my personal digital assistant and, between fiery crashes, the Grand Pooh-bah approaches me with a design requirement. He's got a customer that needs a controller for some custom lighting. This lighting system requires analog input voltages ranging from 1-24VDC, one control signal per lamp. The load on this analog control voltage is expected to be light, no more than 10-20mA. The end system will be part of an RS-485 network but, for the short term, the device needs to be a single control node. The RS-485 and communication/control protocol will be tackled later in the design cycle. One last got-cha, the whole thing has got to fit in a 3"x2" box and each node must control four lamps.

After the Grand Pooh-bah shambles away, I'm faced with a daunting task. How can I quickly get back to my Lunar Landing practice? After all, NASA could call at any time looking for that one engineer capable of rescuing stranded astronauts from our rocky neighbor in the sky. This design calls for a BASIC Stamp and, in particular, the BASIC Stamp 2 (BS2).

The Hardware

The BS2 can generate analog signals with the PWM command. But this command cannot be executed in conjunction with receiving communication strings (which will occur later in the design cycle). Furthermore, the PWM command cannot generate different analog voltages on four pins at once. So, using the PWM command is out. It looks like we'll have to rely on a stand-alone four-channel DAC. The MAXIM MAX5250 has plenty of resolution (10 bits), as well as a serial peripheral interface (SPI) which conserves BS2 I/O lines and makes use of the SHIFTOUT command for simplified software control.

The MAX5250 has some internal feedback connections which allow the designer to access some internal gain circuits. For this design, we can eliminate eight resistors by tying the feedback pins directly to their associated analog outputs. See Figure 1 for a better understanding of where these pins are located. Also, by using a 2.5V reference diode (such as the National Semiconductor LM4040BIM-2.5), you can squeeze a little more accuracy out of this design. What you're left with is a 10-bit DAC with an analog output ranging from 0-2.5VDC. This translates to 2.5V/1024bits, or 2.44mV/bit. This is definitely less than the specified 0-24VDC, but does act as a building block for this system.

The next step in this design is to get the voltage gain up from a maximum of 2.5VDC coming from the MAX5250 to at least the 24VDC required by this design. Tied into the gain concept is a second consideration for this system: feedback. It is possible that your load might change, or fluctuate, after you set your DAC's output voltage. This fluctuation can affect the output voltage and cause the overall system to perform poorly. Ideally, you would want to continually adjust your output voltage based on changes in your load. You could tie an analog-to-

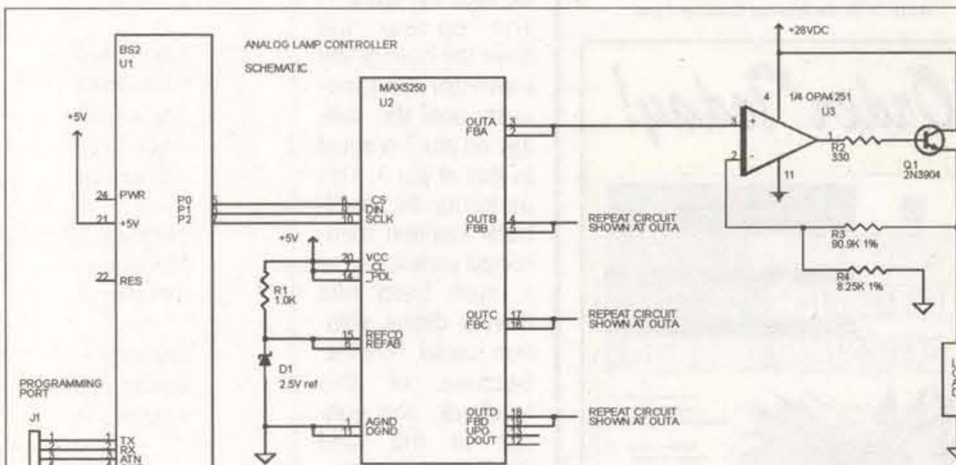


Figure 1: The D/A amplifier schematic

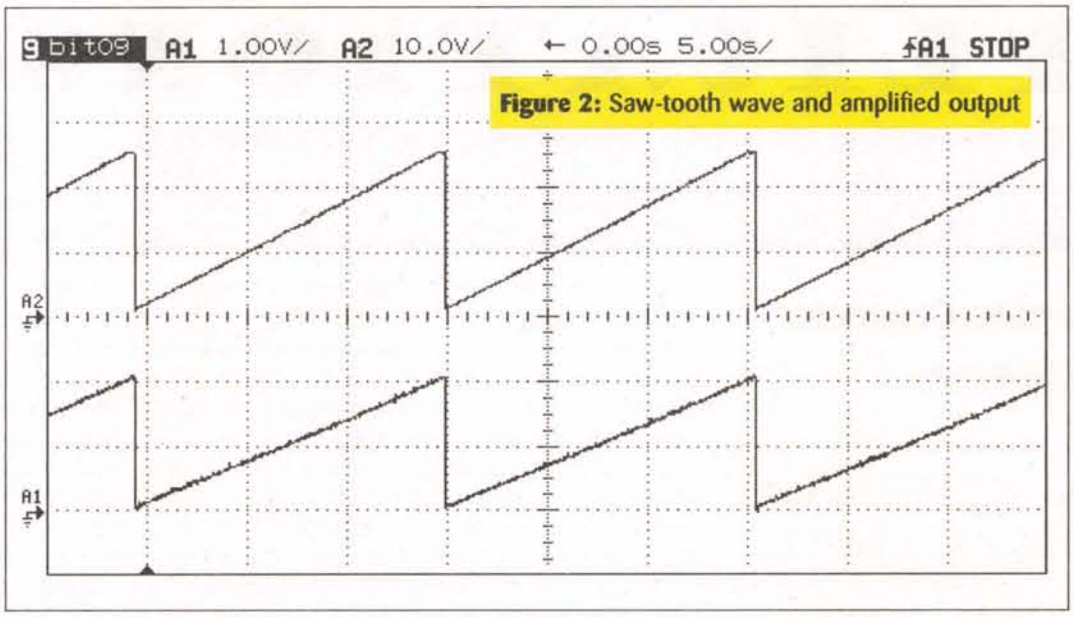


Figure 2: Saw-tooth wave and amplified output

digital converter (ADC) to your output and read the analog signal that your DAC is creating. But this creates a more expensive and very slow feedback system. This problem can be handled in a more intuitive manner.

An op-amp is an ideal element for increasing, or gaining, the voltage potential for any given system. But many small op-amps, particularly surface-mount products, cannot source large amounts of current while spanning large voltage ranges. To optimize the voltage range and current source capability of this system, we'll use the op-amp and NPN configuration detailed in Figure 1. The op-amp will drive the base of the transistor continuously until the voltage on pin 2 is equal to that at pin 3. This performs the feedback function mentioned earlier, and at a much faster rate than a digital solution could provide. Because of this feedback, the voltage at the load (emitter of the transistor) is set by the voltage divider created by R3 and R4. The load voltage will be 12 times the voltage generated by the DAC. The voltage divider for this circuit can allow the output of the transistor to reach 30VDC. For this to occur, the supply would have to be increased, and the op-amp selected must accept this increased voltage level (the Burr Brown OPA4251 is a quad, single-supply, op-amp, which can accept up to 36VDC as an upper voltage rail).

In this circuit, the 2N3904 NPN transistor is used as a pass element to provide current to the load and as an element that drops voltage, thus maintaining its emitter voltage at the level required by the DAC's output. For systems requiring more than the specified 10-20mA of current, different transistors can be selected. Transistor packages that can dissipate more power and are designed for heatsinking (such as the TO-220 or TO-3) can also be used as pass elements and can significantly increase the current source capability. The base resistor may also be adjusted based on the Beta value of any selected transistor, and can be used to limit current in shorted loads.

This system consisting of the DAC, op-amp, and transistor configuration is relatively inexpensive and takes up little room. The step size of voltage control is equal to the

```
Code Listing 1: DAC_AMP.BS2
'DAC_AMP.BS2 writes to the MAX5250 4 channel 10-bit DAC
'generating a saw-tooth wave

        CSpin         CON     0        'DAC chip select
        SDOpin        CON     1        'Data out from BS2
        CLKpin        CON     2        'SPI clock pin

        DACaddr0      CON     $1000    'DAC 1 address
        DACaddr1      CON     $5000    'DAC 2 address
        DACaddr2      CON     $9000    'DAC 3 address
        DACaddr3      CON     $D000    'DAC 4 address
        DACwrite      ON      $4000    'DAC write data to outputsz

        DACreg        VAR     WORD     'DAC voltage value register
        DACloc        VAR     WORD     'Location for voltage value
        SPIreg        VAR     WORD     'Register sent with SHIFTOUT

        DACreg =      $0000            'Default to 0V out
        HIGH          CSpin            'De-select DAC
        PAUSE         500


START:
        FOR           DACreg = 0 to 820
        DACloc              = DACaddr0    'Load DAC zero
        GOSUB         WRITE_TO_DAC
        DACloc              = DACaddr1    'Load DAC one
        GOSUB         WRITE_TO_DAC
        DACloc              = DACaddr2    'Load DAC two
        GOSUB         WRITE_TO_DAC
        DACloc              = DACaddr3    'Load DAC three
        GOSUB         WRITE_TO_DAC
        DACloc              = DACwrite    'Update DAC outputs
        GOSUB         WRITE_TO_DAC
        NEXT                              'Get next voltage value
        GOTO          START

WRITE_TO_DAC:
        SPIreg        = DACreg<<2         'Shift voltage value by two bits
        SPIreg        = SPIreg+DACloc     'Add address to voltage value
        LOW           CSpin               'Select DAC
        SHIFTOUT      SDOpin,CLKpin,msbfirst,[SPIreg\16]
        HIGH          CSpin
        RETURN
END:
```

DAC's voltage output resolution (2.44mV/step) times that of the ratio of the emitter voltage divided by the voltage at the op-amp feedback signal (this is set by R3 and R4 and equals 12). The end result is that each voltage step requested by the BS2 will equal 2.44mV*12, or 29mV, at the emitter of the transistor. Over a range of 24V, there are about 820 discrete steps. The ratio of R3 and R4 could be further adjusted to force the entire span of DAC steps (1024). You would do this by setting the R3 and R4 voltage divider to 9.6 (instead of 12).

RESOURCES

For more information on the BASIC Stamp, contact:

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Fax: **530-891-1643**

Parallax, Inc.
3805 Atherton Road, #102
Rocklin, CA 95765
phone **(916) 624-8333**
http://www.parallaxinc.com

Scott Edwards Electronics, Inc.
1939 S. Frontage Rd. Ste. F
Sierra Vista, AZ 85635
phone **520-459-4802**
fax **520-459-0623**
www.seetron.com
info@seetron.com

The Software

The software required to interface to the MAX5250 is quite straightforward. The SHIFTOUT command is used to generate a saw-tooth wave on each of the DAC's output pins. The first four calls to the WRITE_TO_DAC subroutine load the new DAC output value into the appropriate buffer registers. Finally, the fifth call to the WRITE_TO_DAC subroutine updates all of the output registers and causes the desired voltage to appear at the DAC output pins. Figure 2 shows the software in action.

One bit of information can help to clarify the code. Each DAC in the MAX5250 has a separately addressed buffer register. The voltage value is loaded into this register. In order to access the correct DAC, you must also send an address that is associated with a particular DAC. The exact format that the MAX5250 requires can be located in the data sheet for the part (which can be downloaded from www.maxim-ic.com). In the WRITE_TO_DAC subroutine, the desired voltage is left rotated two bit places and the desired DAC address is added to the result. This process places the data into the format required by the MAX5250.

Figure 2 displays the output of the DAC on A1, and the amplified output at the emitter of Q1 on A2. Sending 820 consecutive 30mV steps generates the saw-tooth wave. The period of this wave is quite slow, but could be sped up by changing the step size associated with each DAC update. The code in Code Listing 1 sends the same value to all four of the DACs in the MAX5250. You could just as easily send four different values.

In Closing

This analog output system is highly accurate and very versatile. Furthermore, it uses very few of a BASIC Stamp's resources. Changing the DAC, op-amp, or transistor can provide a wide variety of cost savings, and/or performance increases for your particular system. This kind of configuration can be used for signal generation for triangle-, square-, or sinewaves. You may even place smoothing filters between the DAC and the op-amp to generate "clean" sinewaves at your output.

Goodbye

This will be my last article for *Nuts & Volts*, and it has been very enjoyable interacting with all of the Stamp enthusiasts that I have been in contact with. Unfortunately, being part of a growing company requires that I devote my resources to internal projects. It is also a good idea to get some fresh blood into the Stamp Applications cockpit every now and then, so that new innovative ideas can come to light.

In closing, I would like to thank the folks at *Nut & Volts*, and the readers of this column, for the opportunity to contribute to the Stamp community. I would also like to thank Parallax for their support, and for the excellent products that they provide. **NV**

Newsbytes

HARDING ENERGY'S QUEST GOLD NiMH RECHARGEABLE BATTERIES WIN EDITOR'S CHOICE AWARD FROM PC PHOTO

Fast-charging nickel metal hydride batteries win praise for performance in digital cameras

Quest Gold nickel metal hydride (NiMH) rechargeable batteries from Harding Energy, Inc., were recently named as an Editor's Choice by PC Photo Magazine. Available in AA and AAA sizes, Quest Gold NiMH rechargeable batteries were chosen for their outstanding performance in notoriously power-hungry digital cameras.

"With the growing popularity of digital cameras, demand is increasing for batteries that can meet their high-drain demands," said Dan McAdams, president, Harding Energy, Inc. "Quest Gold Batteries are specially designed to deliver more power over a longer period of time, allowing digital camera users to take up to twice as many pictures — on a single charge — as nickel cadmium batteries (NiCAD), and up to 10 times as many pictures as alkaline batteries."

The editors at PC Photo said, "We love any battery that lets us shoot longer, especially when it's rechargeable. Quest Gold NiMH rechargeable batteries are memory-free and fast-charging, so we don't have to worry about running out of energy."

In addition, PC Photo editors appreciated Quest Gold NiMH batteries because, in the long run, they are cheaper and better for the environment.

According to McAdams, three products are now available with Quest Gold NiMH rechargeable batteries:

- A four-pack of Quest Gold 1500mAh batteries, AA or AAA size, $24.99 suggested retail.
- Four Quest Gold batteries with a 16-hour, overnight charger, AA or AAA size, $34.99 suggested retail.
- Four Quest Gold batteries with an eight-hour AA and AAA Smart Charger, $39.99 suggested retail.

The primary distributor for Quest batteries in the US and Canada is Minolta Corporation, Ramsey, New Jersey. For information on how to become a Quest battery dealer, contact Jeff Van Scoyk, national digital sales manager, Minolta Corporation, 303-699-7262, or e-mail: jvanscoyk@minolta.com.

Harding Energy, Inc.

Harding Energy, Inc., headquartered in Norton Shores, Michigan, is the only battery manufacturer in the world exclusively dedicated to nickel metal hydride (NiMH) technology, from cell assembly to custom battery pack design and construction.

Harding Energy's batteries are manufactured using American invented, patented, and proven technology. They are produced in a state-of-the-art facility in Michigan by dedicated battery experts committed to quality and excellence in manufacturing better energy solutions.

This modern facility includes a fully-equipped quality control department, where materials and components are rigorously tested before being released to production, and where finished products are inspected prior to shipment.

Harding Energy is a true single source supplier, offering a full range of battery designs and packaging. The company is experienced in all aspects of cell manufacturing, custom battery pack and charger design, and assembly.

These diverse capabilities result in significant cost savings to the customer and reduced lead times. The Harding Service Program adds value to the customer's product(s) through design and component optimization and the efficient manufacture of a high performing, high quality battery product.

Please visit the Harding Energy web site at www.hardingenergy.com.

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Open Channel

by Joseph J. Carr

Mystery EMI: Rusty Downspouts and All That

> Over the years, I've serviced a lot of different problems of EMI/EMC, including residential, business, industrial, and mobile. Some of them are pretty funny.

This article will deal with some of the EMI oddities that I've seen or heard about over the years. One of the things that comes along with radio communications is electromagnetic interference (EMI), and the necessity for electronic products (communications and otherwise) to possess electromagnetic compatibility (EMC). It's not always so easy. The problems of EMI/EMC afflict all communications: commercial, governmental, Citizens Band (CB), and amateur radio. It's one of the things these services have in common.

Moodie and the Crown Vickie

During a much, much earlier period of my life, I worked installing both CB and landmobile two-way radios, as well as ordinary automobile radios. One of the main jobs for an installer of mobile electronic gear is to locate and suppress interference sources. And vehicles abound in such sources!

The ignition and the charging system are prime culprits, but also causing problems are things like the gas-gauge sending unit, power windows, and almost anything else electrical. Today, we have a number of digital processors and computers on board, as well as the traditional noise sources.

Even if your field of interest is limited to eliminating mobile ignition system noise, the task can be daunting. I've seen cases where an ungrounded hood caused massive noise problems. And the fiberglass hoods found on some cars are absolutely evil if the bonding comes loose!

In other cases, noise is induced on the DC power lines that pass through the firewall from the engine compartment to the passenger compartment, where it is re-radiated and picked up by the electronic equipment. In some cases, an ungrounded engine exhaust pipe will re-radiate noise as effectively as an antenna.

All of those things are routinely found. But some are not so routine. Once (if you will permit me a nostalgic regression), I was working installing CB sets at the dawn of the CB era (late 1950s and early 1960s). The vehicle was a 1956 Ford Crown Victoria sedan (which was NOT an antique car in those days).

I tried everything in the technician's bag of tricks, and the CB kept clicking with ignition noise all across the band. The master technician, a rough and ready fellow named Moodie, came down to the garage, determined to "... show that Carr kid how it's done." He inspected my work and could find no fault. He tried a few things himself, and after two hours was still unsuccessful (it was already 7 PM, an hour after closing time).

At that point, weary from lack of success (not to mention a two-hour chewing out by Moodie), I leaned my elbow against the chrome roofline of the Crown Vicky. The noise stopped! One of the features that distinguished the '56 Crown Vicky from less costly models was a nine-foot long curved chrome decoration strip around the front of the roof line, continuing on to the two sides of the vehicle.

Get the point? Nine feet is a quarter wavelength at the 11-meter (27 MHz) CB, so even minute amounts of radiation would find a resonant situation and re-radiate right into the antenna! Cleaning and resetting the clips and screws that held the chrome strip fast solved the problem ... and we were able to get outta there and go home.

The High Hum Level — FM Broadcasting Station

During that same period I worked part-time for an AM/FM broadcaster (I had what they called an FCC "first phone" license in those days). They were mostly country music in the past, but had just started carrying what passed for "folk music" in those days. FM broadcasting was relatively new, and only then were large numbers of FM broadcast receivers being installed on hi-fi sets. In previous times, FM receivers were add-ons to AM designs, so tended to be low-fi. No one noticed the 60 Hz hum that permeated the signal because their receivers' audio rolled off considerably above 60 Hz (the -3 dB point was usually about 200-300 Hz).

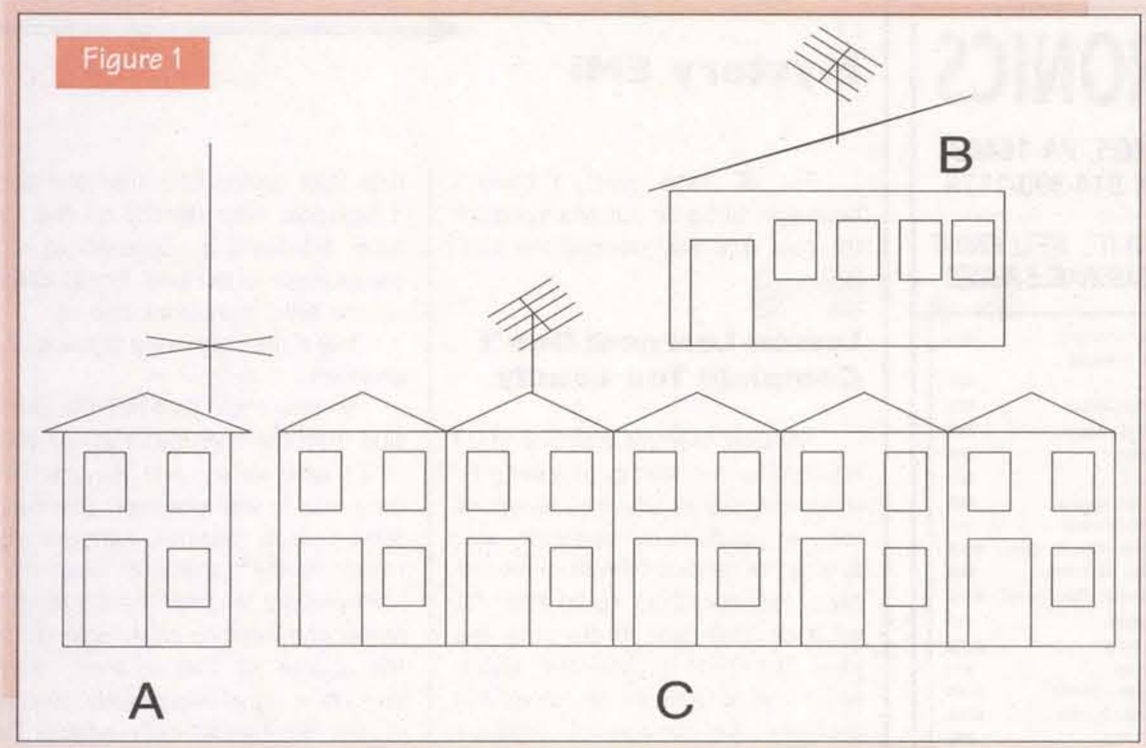
But when Dick Cerri's Music Americana went on the air, a lot of listeners called in and complained. The audience for that show had a lot of hi-fi owners ... whose equipment worked really well at 60 Hz. That hum was a huge component of the signal.

The problem with that system was that someone managed to install a new studio and never even considered using a common ground. One night, the chief engineer showed up with a roll of copper roofing flashing (seven inches wide, 1-lb/ft^2), a foot-square 1/4-inch copper plate, some tinned copper braid ... and a drill. We placed the copper plate underneath the disk jockey's desk, and ran bonding braid from all pieces of equipment to that plate.

The copper flashing was routed down the back of the desk, under the wall (it was fake wall), to the transmitter. The flashing was bolted to a grounding surface on the footers of the transmitter. Unfortunately, there were no connectors and I got to break three bits on some of the hardest steel I've seen trying to fasten that darn copper flashing.

When the chief engineer measured the hum before and after, we were certain to

Figure 1



have achieved at least 50 dB of suppression. It might've been more, but that was the limit of our test equipment.

The Slack Coax Caper

Some years later, I was at Old Dominion College in Norfolk, VA, and working part-time to pay my way. Another rough and ready fellow was named Dexter. He was a fellow ham radio operator (which is how I met him), but he was also a broadcast engineer for one of the larger independent AM broadcast stations in the area. In his part time, ol' Dexter would found new FM broadcast stations, get the license, rent it and his station in his garage to budding new broadcasters, and sit back and collect the money (which is how the Christian Broadcasting Network radio network began).

The broadcaster would stay in Dexter's garage until they could build their own transmitter and get it FCC approved. I was rather amused when someone showed me a copy of a book by televangelist Pat Robertson that showed the Christian Broadcasting Network's first FM station ... it was a clear picture of Dexter's garage.

One day, I was riding with another ham operator on the way over to Dexter's house. We were listening to another station, but were soon pretty certain that the interference we were hearing was coming from Dexter's transmitter. It was all up and down the FM band! Every half megahertz or so, there was Dexter's FM signal. The signal itself was really broad on its own frequency. When we got over to the house we ran inside and told ol' Dexter what we heard. "[Darn!]" – not his real word – "the shoestring slipped again." Huh? The what slipped?

We followed Dexter out to the garage and watched him open the rear door of the transmitter. Oddly, the thing didn't go off the air (the door AC interlocks were all shorted! Don't try that at home, kiddies!). The deviation meter was slashing back and forth, rather than oscillating about a fixed (legal) point. The 1,000-watt final amplifier was in one deck of the 19-inch rack, and the exciter/modulator were in another deck. The coaxial cable between them had a black piece of shoelace dangling free.

Dexter pushed the coax over to the side of the cabinet, and refastened the knot that secured it. Sure enough, the deviation meter settled down, and a quick check on my buddy's car radio showed the problem cured ... even though the car radio was close enough to the antenna to be overloaded.

Open Channel

Mystery EMI

For all these years, I haven't been able to figure out why tying off the coax that way stopped the oscillation.

Lesson Learned: Don't Complain Too Loudly

My next example was one that I handled for a customer of a radio-TV shop, but also as a ham radio operator. A local ham operator was accused of causing television interference. His neighbors could hear his voice on their sets. In our area, the local FCC Field Engineering Office relied on volunteers to solve TVI problems for commercial, amateur radio, and CB stations, and I was one of the volunteers. Consider Figure 1. The interfering signal was located in a duplex house ("A" in Figure 1), and it had a vertical antenna.

Although the guy was a ham operator (whom I knew personally) he was actually using a CB set. Because he was operating the CB legally, he had only four watts or so RF output. It was the CB set that was causing the problem. Four watts? You gotta be kidding.

I checked the output of the transmitter, and it was right at four watts. I then inserted a pretty heavy duty low-pass filter with a 35 MHz cut-off frequency and a very sharp roll-off slope. The output of the CB set went down only a very small amount equal to the insertion loss of the filter. That's a good sign that there was no significant harmonic radiation (a spectrum analyzer would be better!).

Other tests showed that there were no spurious emissions of any sort. Yet the interference persisted even with the filter in-line. Grounding was ruled out.

Figure 1 shows the approximate geometry. The buildings were separated by not more than 50 yards or so. The CB rig was at "A," and the complainants were at "B" (a single family home), and "C" (townhouse block). One of the loudest and most profane of the complainers was the president of the townhouse homeowner's association. The guy was a real jerk.

My first attempt was to solder a high-pass TVI filter directly to the antenna terminals of the tuner inside the TV set at "B" (I was also a qualified consumer electronics Certified Electronics Technician). The problem persisted. The interference didn't even abate. That's not supposed to happen, by the way. Putting a low-pass filter on the HF transmitter and a high-pass filter directly on the TV tuner front-end is supposed to nip the problem in the bud. Right? After all, the ARRL Handbook said so.

Not if the interfering signal is on-channel!

So how could that be? The emission from the transmitter at "A" was at 27 MHz or so, and the interference was to VHF television channels, some which weren't harmonically related to the transmitter frequency. I borrowed a Stoddard Field Strength Meter and went to work looking for the source of the problem. Sure enough, a signal was present on one of the non-harmonically related TV channels ... and it got stronger and stronger as I got closer to the townhouse block ("C").

The problem turned out to be quite simple. The townhouse block had one television antenna in the center of the cluster (antennas were frowned on, and cable hadn't been installed in that neighborhood), so they used a Master Antenna TV (MATV) system. A single high gain antenna served the entire block. To give it enough signal, there was a 60-dB wideband amplifier at the antenna "head end."

My more physically fit buddy climbed into the attic of the townhouse cluster and turned off the amplifier, while the CBer at "A" was transmitting. Simultaneously, the interference at "B" also disappeared!

We later pieced together what happened. The front-end RF amplifier transistor (a PNP Germanium unit) was leaky (weren't most of 'em in those days!), and it was easily saturated. When the CB signal was picked up on the twin-lead transmission line (they didn't even use coax from the antenna to the amplifier!), it was rectified by the RF amplifier transistor. This created a large number of harmonics.

To make matters more interesting, there were also a large number of TV and FM signals applied to the amplifier, as well. These mixed together to produce a mish-mash of intermodulation products ($F = nF1 \pm mF2$) that were re-radiated back out the TV antenna. Unfortunately, for many of the frequencies, the antenna was not only resonant (making the re-radiation very effective), it produced gain. The overall result was interference to both "B" and "C" sites.

I proved that the amplifier was causing the problem (and have since learned that was not a rare case!),

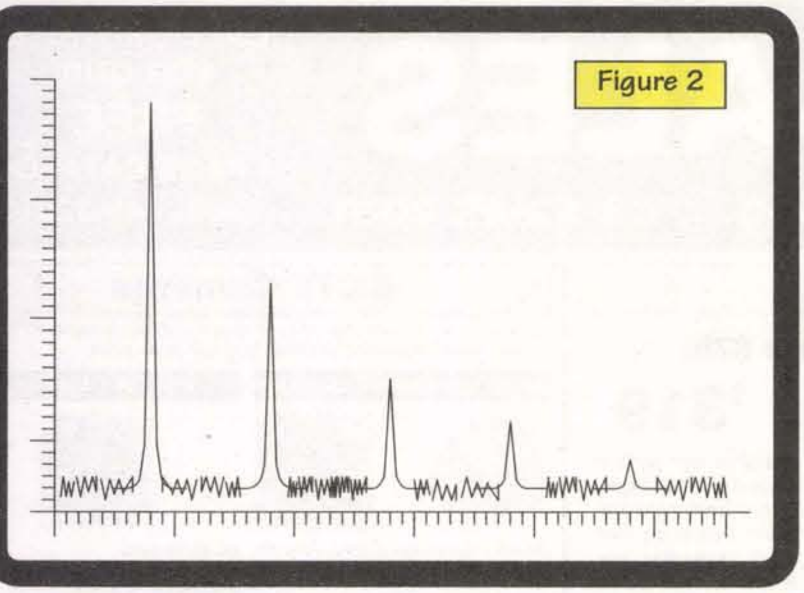


Figure 2

but the president of the homeowners association still complained that it must've been the CBer's four watts that wrecked the amplifier. You can't win with some people.

One lesson learned: Keep your blaming, rebuking mouth zipped until you know for sure where the fault lies ... it might be in your own house (do I hear someone talking about people in glass townhouses?).

When doing EMI troubleshooting on radio transmitters, look for spurious emissions (parasitics) and harmonics from a transmitter using a communications receiver, field strength meter, or a tunable wavemeter. Today, we would probably use a spectrum analyzer, rather than a field strength meter. These instruments are essentially swept receivers with the output displayed on a cathode ray oscilloscope (CRO) as an amplitude-vs.-frequency plot (Figure 2).

If the spectrum analyzer is used, then it becomes really easy to check the output of a transmitter to see if the harmonics are legal. If the rules call for a harmonic to be -40 dBc (decibels below the carrier), then it becomes immediately apparent on the spectrum analyzer if the spec is not being met. You can also see if any other signals are present, and do a site analysis to determine the possible combinations of signals.

Once you work the $F = nF1 \pm mF2$ equation, then you can tell something about the nature of interference (and what possibilities exist). You can also determine which frequencies to filter out far more effectively than the old guessing methods.

Spectrum analyzers can be quite expensive. It's possible to pay $40,000.00 for one. But today you can also buy commercially-built spectrum analyzers for less than $2,000.00. Some of these work by using your oscilloscope as the display, while others have a built-in oscilloscope.

Rusty Downspouts

When rain gutters and downspouts were made of either copper or steel, rather than aluminum or plastic, there was a possibility that EMI could occur when the joint between the downspout and gutter corroded. The oxide layer formed a natural PN junction with the metal, so would rectify any RF signals that appeared on the downspout or gutter.

The lengths of those pieces were long enough to pick up signals at relatively low frequencies. Some people claim this effect was seen quite frequently, but it may be in the realm of techno-myth. Keep it in mind, however, whenever you see harmonics that are difficult to track down. It may be true. Corroded items in the vicinity of any transmitting antenna could be a culprit.

Conclusion

These cases of EMI are humorous, but they actually happened. Hopefully, you won't see anything so bizarre, but if you do, I would like to hear about it. **NV**

Connections ...

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA 22041, or via E-Mail at CARRJJ@AOL.COM.

ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:

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or by snail mail at

Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.

What's Up:

Heard the last of Y2K? Two ways for PCs to share one monitor, two FM voice links, some LED fun, and the usual parts search; new source discovered. An excellent data acquisition Web site, and when DSS TV may be the solution, not an indulgence.

Two PCs, One Monitor

Q. I have an old 286 PC which I use for a file server. Most of the time it just sits there with the same information on its screen, and I rarely have to do anything on the keyboard. It has an old Hercules card with a nine-pin type-D output jack. I would like to take the monitor off it, if possible, and feed the output of the video card into my VGA monitor via a switch box. Can the output of an old Hercules card feed a VGA monitor? If so, do you have a wiring diagram. I don't need anything fancy, I just need to occasionally see what is on the file server's screen.

Gary DePietro
via Internet

A. If I remember my Hercules cards correctly, this card has an EGA (Enhanced Graphics Adapter) output, which is digital, not analog. So the answer is no, it won't work with your VGA monitor. Of course, you could build a DAC switch box that converts the digital output to analog, but that's a lot of expense and trouble. Here's what I'd do. Replace the Hercules card, which plugs into an ISA slot, with a cheap VGA video card. The rub here is that nearly all VGA cards sold today are SVGA (Super VGA) that plug into PCI slots, which your 286 motherboard doesn't support. However, ISA VGA cards are plentiful and cheap, if not free. I had a ton of them that I donated to schools and organizations. My suggestion is to contact a local PC user's group. Chance is good that somebody has one hiding in a closet that he/she will just give to you. Your local computer store, hamfests, and swap meets are also fertile ground.

2-way switch box

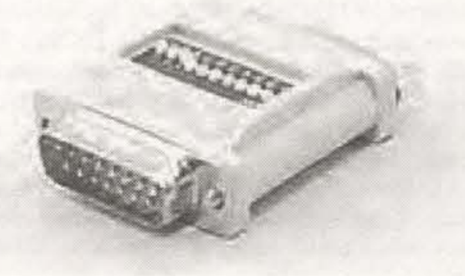
Now you need a video switch box. These are commonly called A/B switches and can be found in most electronic stores. However, most are made for coaxial cable. What you need is a two-way switch box, like the 114155 model from **Jameco (800-831-4242; http://www.jameco.com)** that lets two computers share one monitor. As a bonus, this particular switch box also lets you switch a single keyboard between the two computers.

Mac & PC Share Monitor

Q. As a Mac addict who is feeling marginalized, I've decided to buy a PC to run PC software applications for which Macintosh doesn't have an equivalent (and to learn more about the PC world). I have a perfectly fine 17" NEC MultiSync monitor that I'd like to time-share between my PowerMac 7200/90 and my new PC in order to save money and precious desk space. What I haven't found yet is a means of switching the monitor's cable between the drive cables of the two machines. Since my computers and monitor are backed up against a wall in the corner of my small den, it's not easy to go behind them to physically disconnect the monitor cable from one computer and reconnect it to the other. Also, I can imagine quickly wearing out the cable or the cable jacks on the computers that way. What would you suggest for a switching device?

Richard A. "Dick" Rucker, KM4ML
Fairfax, VA

A. First, read the answer to the previous question, then surf over to **Jameco** and buy an AD910 Mac to VGA adapter (126439) and a 15-pin VGA video cable (148523). Plug the adapter into your Macintosh and string the new video cable to the monitor A/B box. That's it! Whole lot cheaper than a new monitor.



Satellite TV Is Cheaper Than You Think

Q. I live in the Santa Cruz mountains and receive two feeble TV stations. When I try to amplify them, it only gets worse. I suspect I am amplifying the noise. Is there a way around this, or is a 25 dB amp overloading the input?

Tom Lakia
via Internet

A. It's called garbage in, garbage out (GIGO). I'd guess you're receiving a bounced signal and, yes, all you're amplifying is noise. When I lived in Canyon Country, I had a similar situation. I was lucky to have access to four very weak stations, and two of them were on UHF repeaters. Anyway, my antenna was a mile away on the top of a peak, and there were three repeater amps in the coax link to my house — each of which I had to custom modify so that the 12 volts needed to power them would pass through. Thankfully, I don't have to do that today. Instead, I get the privilege of paying $30.00 a month for an AT&T cable where the channels don't match up with the local TV guide (nope, doesn't include HBO).

If I had to do it again, I'd go to RadioShack and take them up on their less-than-$100.00 DSS deal. For $99.00 ($149.00 installed) you get a DSS dish and a receiver. I paid more than that for my Wingard antenna alone! Moreover, DSS has 210 channels at last count. The downside is that you have to buy access to the satellite. Prices start at $19.95 and go up as you add premium channels. You can find the prices and everything you need to know at **www.RadioShack.com** or **www.directTV.com**. Bottom line here, go with a satellite system — even if it's not from RadioShack — it's cheaper in the long run.

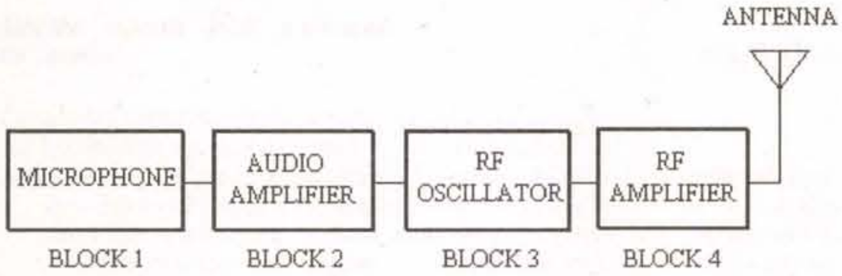
Automatic FM Microphone

Q. My son and I are working on a project to combine a record/playback chip with an FM transmitter. Our goal is a unit that is compact, powered by a 9-volt battery, and cost under $50.00. Our time together has been a very enjoyable learning experience, but we lack the expertise and knowledge to put the two components together. Here are the components that we feel will do the job: The transmitter chip is a Motorola MC13176 and the record/playback chip is Microchip

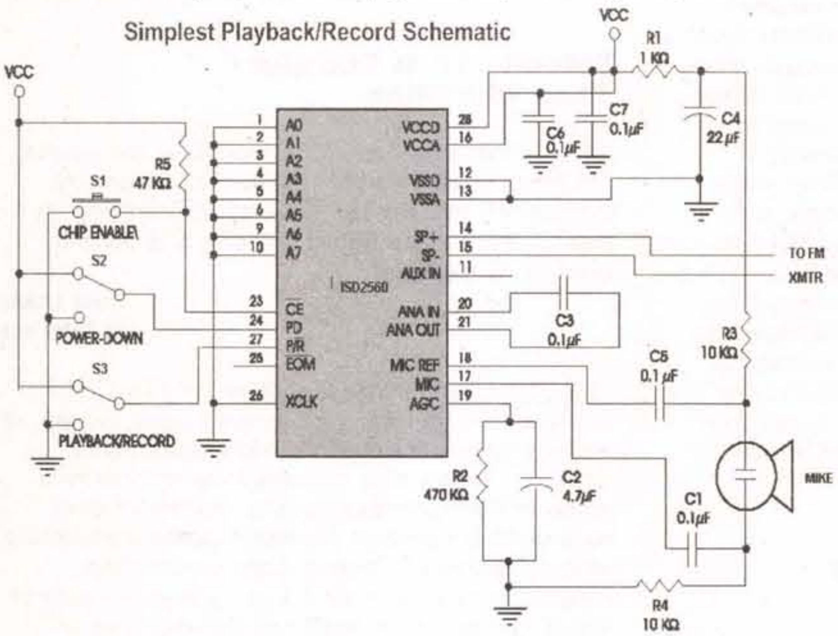
PIC 16C55-RC/P. Any assistance would be greatly appreciated.

Alfred & Cecil Melvin
via Internet

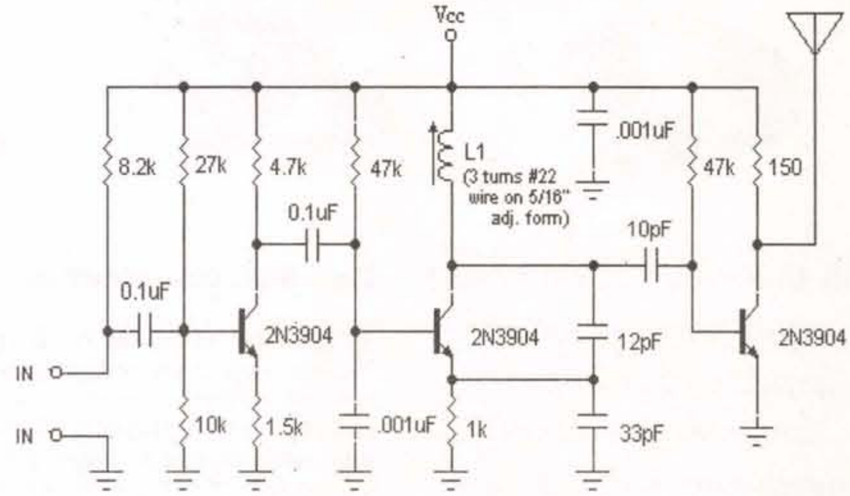
A - Before I begin, let's break this answer into two parts: voice and RF. Here's a block diagram of how the two connect together.

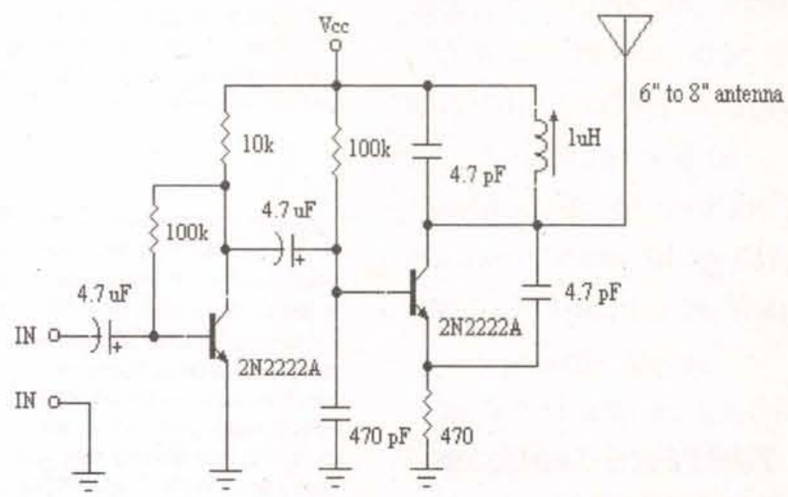


Let's take the speech section first. I've never heard of a PIC 16C55-RC/P, and neither has Microchip (408-544-2625; http://www.isd.com/products). My thought, shared by Microchip, is that it's probably from a company who has a programmer that adds your voice to the 16C55's EPROM. My choice would be the ISD 1000 or 2500 series from **Information Storage Devices (408-369-2400; http://www.isd.com/products)**. RadioShack sells them for as cheap as $6.99. This chip lets you record and playback messages as long as 120 seconds. The next circuit shows the simplest implementation of an ISD 10xx or ISD 25xx chip. The only difference between these chips is the time of the message. If this circuit looks like more than you want to tackle alone, RadioShack sells a prewired voice/playback kit (276-1326) for $19.99.



Onto the FM transmitter. There are two ways to go here. The first, and cheapest, is to use a standard FM radio to receive the signal. This FM band works in the 88 MHz to 108 MHz range, and is the cheapest route. You can build the FM transmitter using either of the two circuits below, or you can build one from a kit, like those sold by **Elenco Electronics (800-533-2441; http://www.elenco.com)**, **Centerpointe Electronics (800-422-1100; http://www.cpcares.com/)**, and others. If you use a kit, you can steal the microphone for the speech section.





If, on the other hand, you prefer working in the more popular hobbyist range of 433 MHz or 900 MHz, **Lemos International (508-798-5004; http//www.lemosint.com)** sells an inexpensive transmitter/receiver pair for $15.50 and $26.00, respectively. It's catalog number is TMX/SILRX (listed as SILRX/TXM on page 85 of this issue). Have fun with your son!

Y2K Defined?

Q - I was playing with the dates on some old 386 PCs the other day and noticed that even though the BIOS wasn't Y2K compatible, I was able to set the date at the DOS prompt to the year 2000. I also tried setting the year to 1972 so the dates would match up with 2000, but was unable to do it; I keep getting an "invalid date" message. So does this mean that the PC is Y2K compatible or just a weird occurrence? If the year cannot be set to 1972, these PCs would be worthless for anything that's date sensitive. I ask this because I also have some older Pentiums in use that aren't Y2K compliant, but are running with the 2000 date.

Kyle Montgomery
via Internet

A - You have just discovered the very thing that fueled the Y2K frenzy. Let me see if I can make sense of it. The IBM PC was invented in 1980, so when IBM burned-in the BIOS — which at that time had to be very small because of the high cost of ROM — they started the clock at 1980. In fact, the original IBM PC had only 64K of RAM (1/16 of a MB), not even enough to load today's DOS. That's why you can't set the calendar to 1972. PCs made by other vendors most likely have the capability of setting the calendar before 1980, but IBM compatibles don't. However, IBM had the foresight to extend the BIOS date to 2099 by including a century byte in the BIOS. Obviously, IBM had long range plans for the PC. Although this century byte (located at &H32) has long been available, and why DOS can change the date to 2000, the software programmers obviously didn't pay attention to it — which is why the software may roll over to 1900 (which doesn't exist in IBM PC BIOS) instead of 2000. What you have to remember is that in those early years there weren't a lot of competent software programmers; and mostly what they wrote were text-based programs or games. It wasn't until about four years ago that the industry took a long look (forest from the trees scenario) and considered this a serious threat — and even then the fixes were slow in coming.

So how do you make your older 386s usable? I'd set the date to 1984. January 1, 2000 fell on a Saturday; January 1, 1984 fell on a Sunday. Both are kissing-cousin leap years, and you can easily adjust the day difference by men-

tally subtracting one day from your daily planner, if you use one. Viola, your old software will run perfectly. Think of it as an Orwell adjustment. Can you set the calendar to 2028, the next exact 2000 match, and have the software run properly? It all depends on how the software was written.

70-Volt Audio

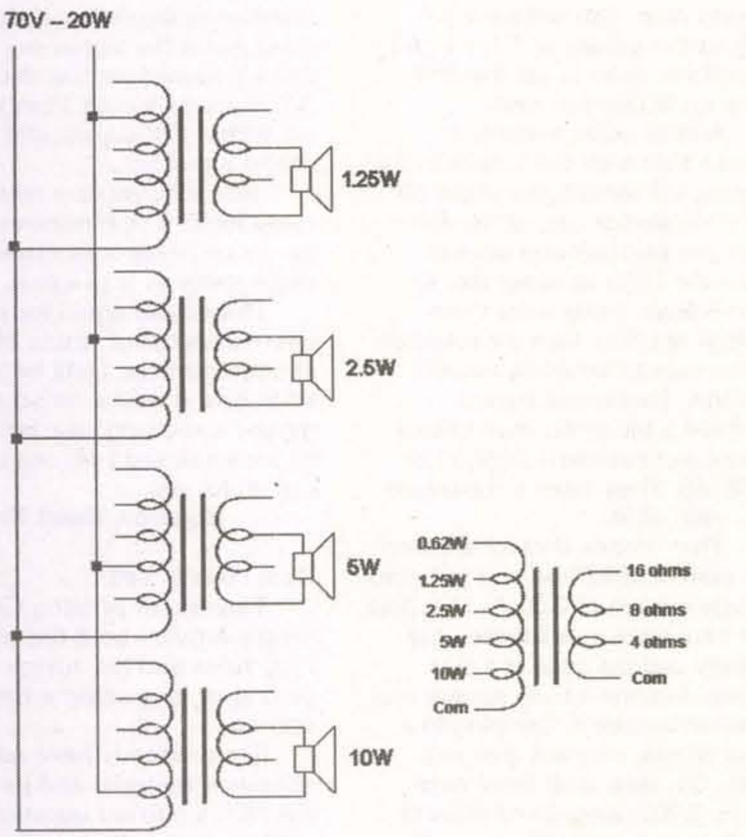
Q - I'm trying to get information about the 70-volt audio distribution which is often found in commercial audio systems. How does it differ from the usual 4-8 ohm home stereo outputs? Is there some way a regular home style receiver with a 4-8 ohm output be used to drive a 70-volt system?

Lowell
via Internet

A - The 70-volt distribution system was developed to convert the output of a PA amplifier to a higher voltage so as to minimize power loss when speakers are located long distances from the amplifier. Plus it simplifies the connection of multiple speakers that do not have the same impedance. Let's use Ohm's Law to analyze the situation. Let's say that the round-trip distance between the speaker wires and the speaker itself is 100 feet, and we're driving an 8-ohm speaker at the other end of the line with a 100-watt amplifier. Let's further consider the round trip resistance of the wire loop is 8 ohms. It doesn't take a rocket scientist to figure this one out. Half the power will be lost in the wiring, delivering only 50 watts to the speaker.

Now if we increase the impedance of the speaker to 70 ohms, then the amplifier will see 78 ohms, not 16 ohms, which reduces the current in the hook-up wire — and the power loss. That's what a 70-volt distribution system does. It sends low-current, high-voltage down the line, where it's converted to high-current, low-voltage at the end via a 70-volt step-down transformer. This is exactly what the power companies do to deliver more power to its customers and loose less. In fact, high-tension wire voltages often run into the millions of volts. The higher the voltage, the less current, and the less power lost.

But that's just the tip of the 70-volt iceberg. The real strength with a 70-volt system is power distribution. Suppose you have a four-story office building and a noisy warehouse you have to pipe sound through. Let's also assume that the ceiling speakers are 8 ohms and that the PA trumpet outside is 8 ohms, too. Obviously, you don't want the office speakers at the same volume as the loading dock's. The 70-volt transformer balances out the sound using taps — not power wasting rheostats. Look at the drawing below.



Notice that the primary has five taps, each of which is designed to deliver more or less power to the speaker. The higher the tap, the lower volume. This method also lets you mix and match speakers of different impedance's. So the ceiling speakers can be 4 ohms and outside speaker 8 ohms. The ability to adjust the volume while you mix-and-match is its strongest selling point.

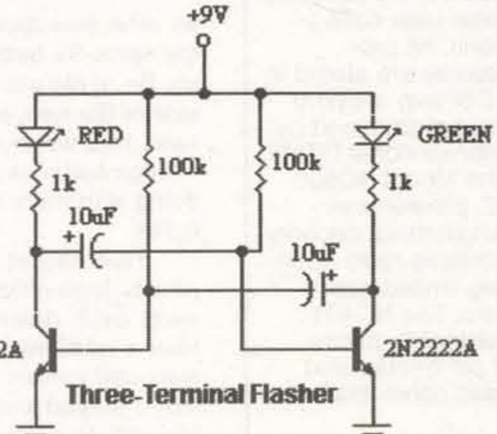
Can you convert a regular 4-ohm amplifier to a 70-volt line? Sure! All you have to do is turn the 70-volt transformer around so that the secondary is the primary, and the primary is the secondary (the one that feeds the distribution line). Just keep the primary leads heavy and short to reduce power loss, and match the size of the transformer to the total needs of the system.

Blinking Bi-color LEDs

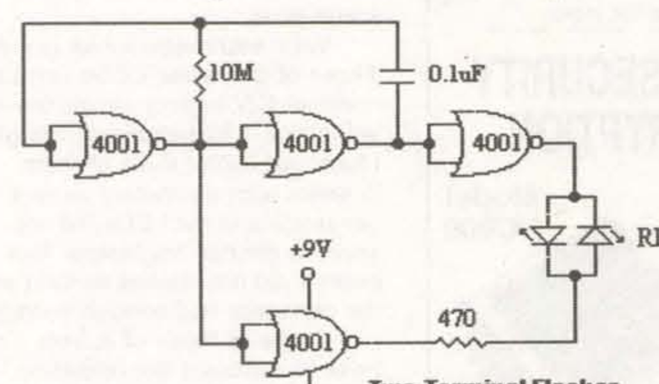
Q - I am looking for a circuit that can flash a bi-color LED. The LED is red with one polarity and green when it's reversed — kinda like a polarity flip-flop. I tried using a 556 timer IC, but it doesn't work all the time. I want to use this in a marquee type of sign for a railroad project. It would be nice if it started slow and increased in speed. Any ideas?

Ray Samples
via Internet

A - There are two types of bi-color LEDs — those with two leads and those with three leads. They are equally popular, so I've included a circuit for each. Because you plan on putting these lamps into a model railroad, I purposely designed these circuits using the smallest components and the lowest part count. I avoided using SMD devices because most readers don't have the tools or expertise to work with them.



Three-Terminal Flasher



Two-Terminal Flasher

The upper circuit is designed for a three-lead common-anode LED — the kind you find in a lot of PCs. The circuit is a very simple flip-flop using just eight parts (nine if you count the LED). The rate at which the LED changes color is determined by the 100k resistors and the 10 uF caps. Smaller caps results in a faster blink rate. If you want to flash a common-cathode LED, replace the 2N2222 transistors with 2N3904 and reverse the polarity of the battery and caps.

The lower circuit works with two-lead bi-color LEDs, like you have. This circuit is a simple astable flip-flop built around a single IC and two passive parts. Normally, this flip-flop uses just two gates, but to get the polarity reversal (and current) needed to drive this LED, two more inverters were added. When the output of one inverter is low (GND), the other is high (+9 volts), and visa versa. The blink rate is set by the capacitor and resistor; smaller resistors increases the rate. Why didn't I use a dedicated flip-flop chip like the 74HCT74? Because any NOR or NAND gate, which are cheaper and easier to find, can be wired as an inverter.

Needs An IC

Q - I'm trying to locate an IC part number AN6251 used in a Pioneer reel-to-reel model RT-909 and designated as IC 501. Any help is appreciated.

Chuck Clark
via Internet

A - http://www.dialelectronics.co.uk

Needs An LCD

Q. Do you know the pinout of the RadioShack LCD Electronic Counting Module (277-302? I lost my data sheet and RadioShack won't open up a new one to let me make a copy.

Name Withheld
via Internet

A. Looking into the front of the counter, pin header at the top, it goes:

1234567
1-GND
2-Reset
3-Counting Input
4-+1.5V
5-Tone output
6-NC
7-NC

Helpful Web Sites

T&M World Online editors have just put together a new section focusing solely on Data Acquisition. You'll find a wealth of data acquisition articles, useful links, product, software, and book reviews and more at **www.tmworld.com/DAQ/daq_index.html**

TJ Byers
Q & A Editor

reader FeedBack

Continued from page 12

an otherwise dark camp. He used the same 9V battery for a week or so. No, it did not light up the other side of the tent, but it let him cook, read, etc., without having to change batteries as he used to doing with more conventional lights.

Fluorescent lights have a relatively high-efficiency light for watts used. However, they must have a relatively high voltage to start and sustain them. That is why I stayed away from them. We will do a piece on inverters some time.

Your arithmetic looks good. Three of the white LEDs across a nominal 12V battery should leave you about 1.5V headroom/margin. I have put two or three of them in series with a constant current generator and the LEDs did not seem to change brightness: The current did not change as long as the generator had enough voltage.

Come to think of it, you have to subtract the reference voltage from the applied voltage. That leaves you with about a two to three tenths of a volt for your margin.

A 12V battery should run close to 13V when fully charged. With about 3V across them, the white LEDs that I used would work. However, it sounds like three LEDs and only 12V would be pushing it close to the lower limit. I think that it will work as you described it, however, the light may start to fade a lot sooner with three LEDs than with just two in series. I have no doubt that you can and will research this for optimum results.

With three strings of LEDs each drawing what, 60-75mA for 25% duty cycle, you should get decent run time between charges. If you are using solar charging, and you have only so many hours of dark, with the lights in use, I would expect them to run much of the night. Again, this sounds like a practical application. As I mentioned in the article, I tend more toward the conservative side.

The units mentioned in the article came from the back of the LED package. I tried to find a definition for it — best guess — millicandle. I suspect that your thoughts on that probably come closest to the correct answer than mine. Sounds like you have made a practical, solar-powered night light.

Evert continues ...

When I sent the note the other day, I was thinking in terms of using Figure 2 to trigger or key the circuit of Figure 4B. However, upon thinking about it for a while, I can see no reason not to put a string of LEDs in place of LED1 in Figure 2. I think that is what you had in mind. You can leave the photocell in place, too. And yes, three LEDs at 3.5V each still leaves 1.5V for the battery to drop. You will have to adjust the values of C1, C2, R1, and R3 in order to get the 25% duty cycle that you want.

A little quick arithmetic shows that with the values in the Figure, Q3 should give about 30-60mA collector current. I believe that you said that you want to drive the LEDs at about the 60-75mA level. If that is for three strings of LEDs, then the total collector current would be around 225mA. That would push a 2N3904 a bit harder than I like. I would recommend a 2N3053 or NTE128. They have a minimum DC gain of 90.

That means that for a collector current of 225mA you will need a base current of 2.5mA. That puts the total resistance between the battery and the base at 4,800 ohms. Assume a fresh battery and a warm transistor. Camping in a cold climate may not give you both. So, allow a bit more base drive; 3,900 ohms gives close to 3mA base current. That would mean changing the resistors on the collector of Q2. Make R4 and R5 1800 each. That would give some isolation for the driver/flip-flop. You may leave out R6.

An alternative solution consists of putting an emitter follower between R5 and the base of Q3. Break the connection between the base of Q3 and that end of R5. Put the base of the new transistor there (cold end of R5). Call the new transistor Q3A. Connect the emitter of Q3A to the base of Q3. Connect the collector of Q3A to the collector of Q3. That makes Q3 a Darlington pair. You can use a 2N3904 for Q3A. I would still recommend a 2N3053/NTE128 for Q3. That will give you an estimated current gain of 150 x 90=13,500. Minimum values for the two transistor types. That would allow you to do what you want to with the values of R4 and R5. You would not have to change them other than as needed, possibly R4, to get the desired duty cycle out of Q1 and Q2.

With that much gain, you need about 15-20 microamps into the base of Q3A to drive the collector to saturation. Keep in mind that a Darlington pair like this will never have less than about 0.75V across it even when saturated. With a 12V supply, that should not be a problem.

Basically, you are using saturated logic. The transistors are turned on or off or as close to those states as is practical.

Thank you again for your interest and your words of encouragement. I will be interested in how it works for you. If I missed something else, feel free to let me know and I will see what I can do for you.

Regards, Evert Fruitman

Dear Nuts & Volts:

Thanks for printing Gordon West's article about the new FCC rules and his advice about getting or upgrading a ham license.

If you already have adequate reference material and just want the FCC's current question pools, you can find them on the web. For example, the advanced question pool can be found at http://www.arrl.org/arrlvec/advanced.html. Some websites include the figures and can generate practice exams.

Gerald Roylance,
Mountain View, CA

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MAX MOD

A low-cost 20 MHz function generator module

by James Lyman

A 20 MHz function generator for $20.00 sounds like the impossible dream for us electronic types, but it's true! A new chip by MAXIM, the MAX038 operates easily to 20 MHz, and yet costs only $19.95 in single quantities from Digi-Key. And this chip not only works beyond 20 MHz, but produces a good clean constant amplitude wave form.

The MAXIM MAX038 function generator chip provides a current-controlled function generator having the three basic wave forms of sine-, triangle-, and squarewaves. It also has a synchronous TTL level squarewave output. The frequency is determined by a single timing capacitor and a current input which ranges from 2.5 to 750 micro amps. The frequency is directly proportional to the input current, and can be swept over a two decade range. A resistor can be used as a voltage-to-current converter, allowing frequency control by voltage. Selection of the output wave form is accomplished by a two-bit digital code.

The MAX038 chip presents a number of neat possibilities for home brew instruments. The MAX MOD function generator described in this article provides a simple-to-build module that you can easily use to build these possibilities. This module can be used to build a simple, high performance, conventional function generator, or a sweep function generator, or a function generator controlled by your computer. Since I was interested in a computer-controlled function generator, I designed the MAX MOD to be operated by digital and D/A analog inputs from my PC. The module includes selectable capacitors for different ranges, digital selection of wave form type, and frequency controlled by a voltage. These control inputs can also be generated manually by using simple stand-alone circuits.

The MAX MOD has three analog and eight digital control inputs. One analog input is 0 to 2.5 volt for control of the output frequency. This input is used for both CW frequency control and sweeping. The second analog input is for fine frequency control and is used for manual operations. The third analog input controls the output wave form symmetry, that is, its duty cycle. While control of frequency is by a voltage, the other two are current inputs which use the chip's internal 2.5-volt reference and variable resistors.

The digital controls for wave form selection consist of two bits. The frequency range selection uses the remaining six bits. The wave form selection inputs are standard TTL levels and go directly to the chip. The frequency range select bits go to the coils of the reed relays that switch timing capacitors in and out of the circuit. These digital inputs are 5 volts that source 10 mA to each relay coil. Note that the outputs for the 16C5X series microprocessors can easily drive these relays directly. For the highest frequency band of operation — 1-20 MHz — no relays are energized. For the next band — 100 KHz-2 MHz — relay K1 is energized. For subsequent ranges, K1 always remains energized, plus an appropriate range selection relay is also energized. See the truth tables for wave form and range selection.

The MAX MOD has three outputs, the first being the actual wave form generated by the chip. The second is the TTL squarewave that is synchronized with the output. This output serves as a handy timing reference for triggering things like oscilloscopes or logic analyzers. The third output is a precision 2.5-volt reference used in generating the analog inputs.

Power inputs are ±12 volts and +5 volts for digital. The 12 volt inputs are regulated down to ±5 volts by internal three terminal regulators. These regulators provide isolation from any external circuitry. You can use the internal +5 volts for the digital supply, but you run the risk of introducing high-frequency noise into your analog output.

CONSTRUCTION

Because of the high frequencies involved and consequent shielding requirements, the MAX MOD is constructed using an RF prototyping technique, referred to as "dead bug" construction. Although dead bug is not an expression most digital designers like to hear, this construction technique — which uses point-to-point connections on a brass board — has been used by both amateurs and professionals since before World War II. A printed circuit board of sorts is used as the brass board, but its construction requires no etching of circuit paths. Referring to the board's artwork in Figure 1, you see that its fabrication is just layout and drilling. If you really wanted, you could etch the copper away from the holes and then drill the through holes, but drilling is easier if you're merely careful. The board is a blank single sided circuit board, either 1 or 2 oz. copper. The holes are for six reed relays and two filter capacitors that are mounted from the back, much as with a conventional circuit board. Since each device has only one of its pins connected to ground, the copper around the remaining pins must be removed to prevent any accidental shorting to ground. Its removal is accomplished by partially drilling a larger hole over the previously drilled through hole.

Start construction of the circuit board by cutting a blank single sided circuit board to the dimensions in Figure 1. Make sure the corners — particularly the lower left hand corner — are square. If the lower left hand corner is not square, the layout of the holes may be off, causing difficulties in mounting the relays. With the copper side up, use the bottom and left sides as the base lines for all measurements in the layout. Carefully measure the center point for each hole, and mark its position on the copper foil using a center punch. A small sharp nail will work fine as a center punch. After you have marked the center position of each hole, drill the holes with a #65, 0.035 dia. bit. Since most of the connections for the relays and filter capacitors are

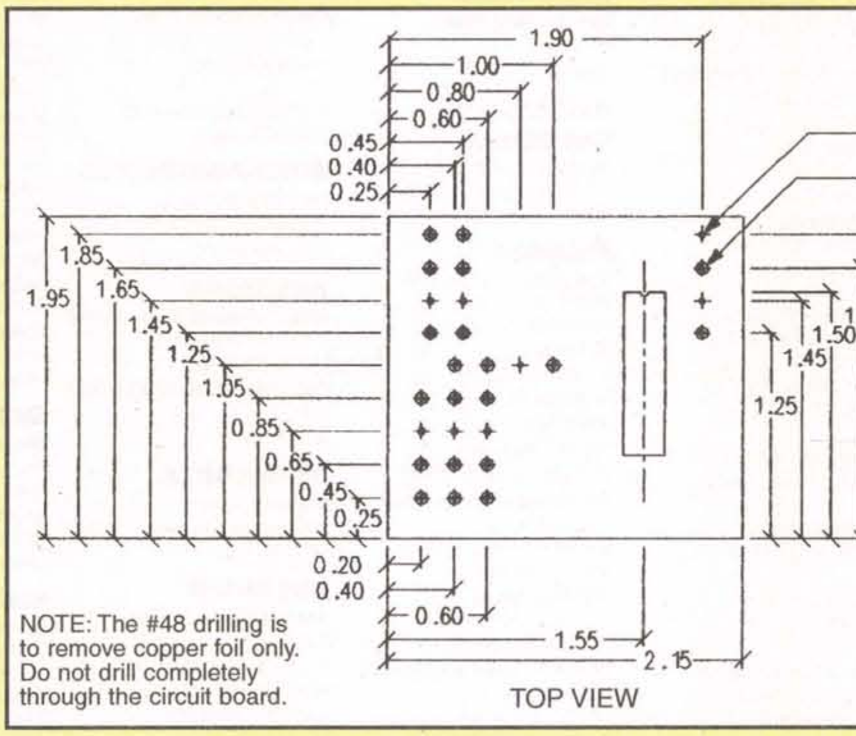


FIGURE 1
BOARD LAYOUT.

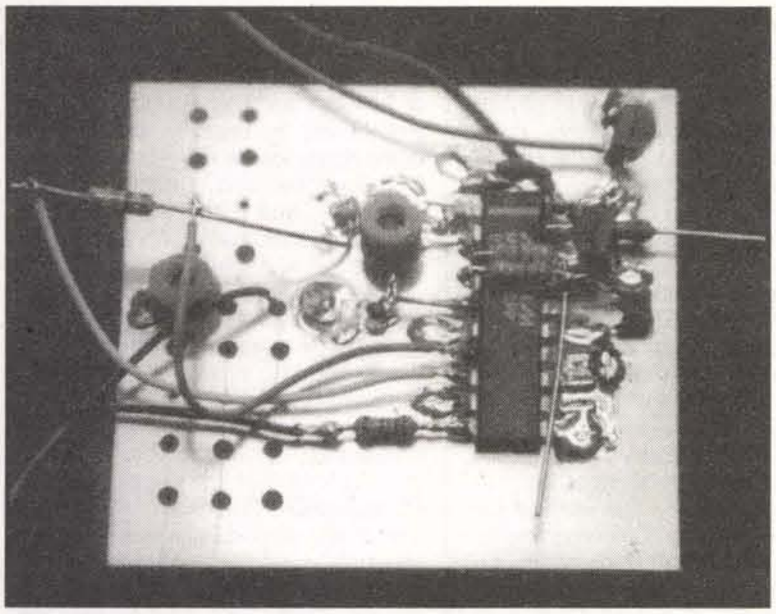


FIGURE 2
MAX MOD PHASE I CONSTRUCTION, READY FOR TESTING.

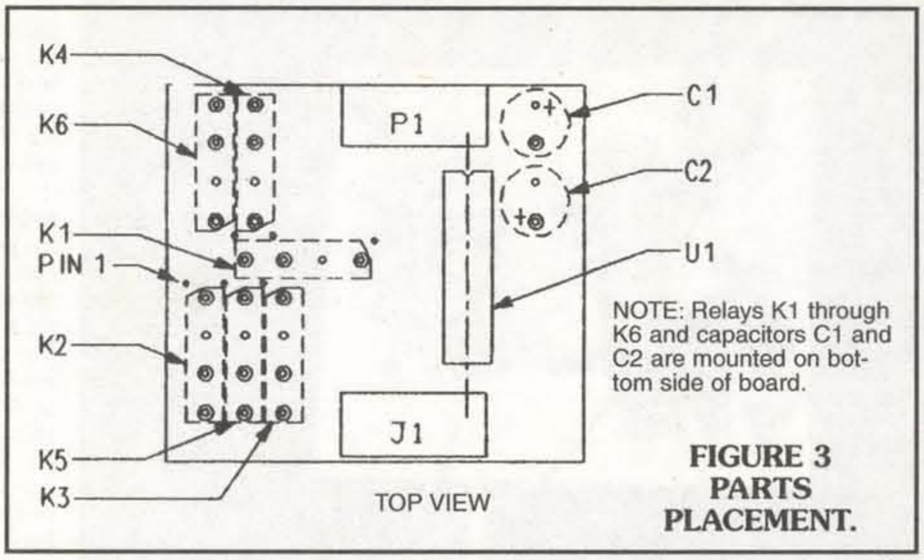


FIGURE 3
PARTS PLACEMENT.

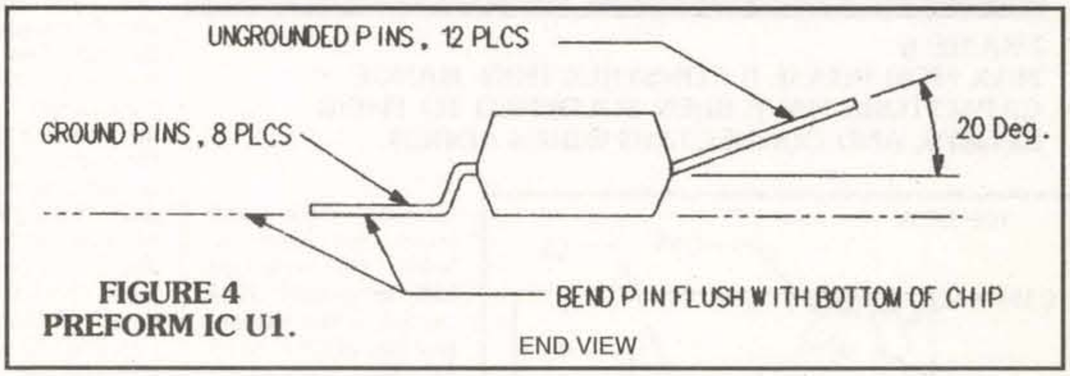


FIGURE 4
PREFORM IC U1.

NOT to ground, the copper foil must be removed from around the holes. The single circles in Figure 1 indicate a single hole through the circuit board with the copper foil going to the edge of the hole. The double circles indicate where copper foil is removed from around the hole. Use a #48 drill (0.076 in dia.) to drill out the copper foil for each hole having a larger circle around it in Figure 1. These larger holes DO NOT go completely through the fiberglass board. You must carefully drill through the copper foil only, and stop before drilling a complete hole. If you do accidentally drill through, you may as well begin again, because it just isn't worth the hassle to save four square inches of circuit board. After you finish drilling the board, clean the copper foil with soap and steel wool. This will make soldering to ground easier.

Phase I Assembly

Since the dead bug method of construction is difficult to modify and rework, I advise building the function generator module in stages. This allows the testing of the circuit before the circuit becomes too cluttered. The first stage of construction is the minimum circuit for functional test. This stage is also the highest frequency range. The sequence of assembly is important to ensure sufficient space between components. Refer to Figure 2 for completed Phase I assembly.

NOTE: All of the following connecting wires are 28 AWG stranded wire cut to a 2-inch length with 1/8-inch insulation stripped from each end, and both ends are solder tin. Because of the number of wires to be connected, it is advisable to use different colored wires. I use wires pulled from multi-colored ribbon cable.

1) First install relay K1 from the non-foil side of the board. Refer to Figure 3, and note the notch on relay's case to indicate pin 1. Solder pin 2 to ground. For now, this connection provides the only mechanical holding of K1.

2) Refer to Figure 4 and pre-form U1, MAX038 chip by first bending all non-ground pins upward to an angle between 10 and 20 degrees above the horizontal plane. The ungrounded pins are 1, 3, 4, 5, 7, 8, 10, 14, 16, 17, 19, and 20. Next, bend the ends of all ground pins horizontally outward, even with the bottom of the chip. These pins should come out from the side, down to the bottom of the chip, and then outward from the chip. The idea is that when the chip is laying flat on the board, the ground pins touch the copper foil. Again, refer to Figure 3. The grounded pins are 2, 6, 9, 11, 12, 13, 15, and 18.

3) Position U1 on the circuit board with the end of pin 5 about 3/16 inch from pin 1 of relay K1. Refer to Figure 3 and note that U1 is perpendicular with K1, thus forming a "T." While carefully holding U1 in position, solder any one of the ground pins to the copper foil of the circuit board. Now check the positioning of U1 with respect to K1. With only one ground pin soldered, you can still shift U1 a little. When you are satisfied with U1's position, solder the remaining ground pins. To avoid over heating U1, keep one finger on U1's top, and quit soldering when it gets hot.

4) Use a lead wire from a capacitor or resistor to form a bridge wire from relay K1, pin 1 to U1, pin 5. Bend the wire into an "L" shape. Trim both ends to bridge between K1 and U1. Very carefully solder the bridge to pin 1 of relay K1. Then solder the bridge to pin 5 of U1. Using an ohmmeter, test for shorting between the bridge wire and ground, which is the copper foil of the circuit board. There must not be ANY connection (short) from the bridge to ground.

5) Preform trimmer capacitor C5 by bending both leads outward and horizontal. Position C5 on the side of the K1-U1 bridge, towards pin 1 of U1, with the flat side of C5's case going to ground. See Figure 5. Refer to Figure 4. Place one lead of C5 on top of the bridge and solder the other lead to ground. With the ground connection holding C5 in place, carefully solder the other lead to the bridge. Again check the bridge to ensure no inadvertent short to ground.

6) Preform the trimmer capacitor C6 by bending the ground lead (flat side of C6 case) outward and horizontal. Cut the other lead to a length of about 1/16 inch. Position the short vertical lead of C6 against pin 4 of relay K1, with the other horizontal lead towards

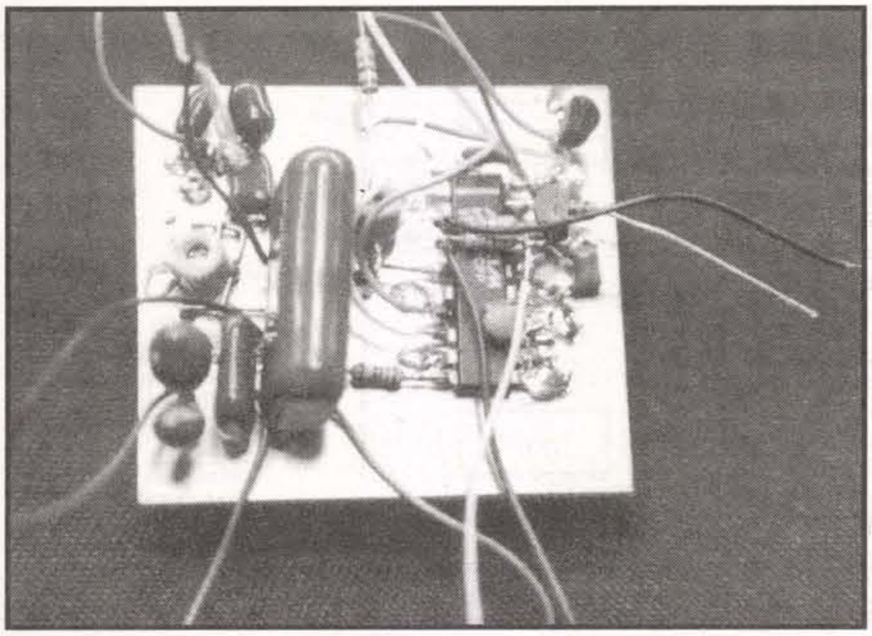


FIGURE 6
MAX MOD PHASE II CONSTRUCTION. RANGE CAPACITORS HAVE BEEN SOLDERED TO THEIR RELAYS, AND CONNECTING WIRES ADDED.

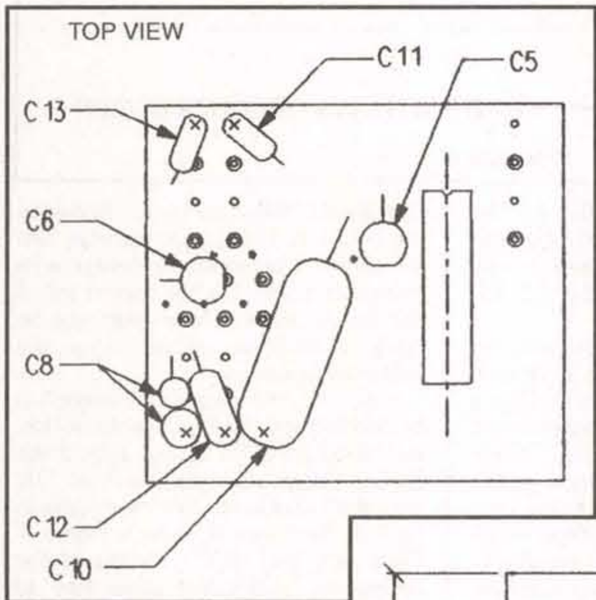


FIGURE 5
RANGE CAPACITOR PLACEMENT.

the edge of the circuit board. See Figure 5. Solder the horizontal lead to ground. Now carefully solder the vertical lead of C6 to pin 4 or relay K1. Again, check continuity between the junction of K1-4 and C6 to ground to ensure there are no shorts to ground.

7) Preform 0.1 uF bypass capacitor C4 by cutting both leads to a length of 1/4 inch and bending both leads horizontally straight out. Looking down at C4's top, bend a small jog in the lead of C4 to offset it from the front of U1. Position the jogged lead of C4 over and parallel to pin 20 of U1 and solder them together. Press the other lead of C4 against the ground foil, and solder it to ground.

8) Referring to Figure 3, install the negative 100 uF filter capacitor C1 with its positive lead through the ground hole. Solder the positive lead to ground. Install the positive 100 uF filter capacitor C2 with its negative lead through the ground hole. Solder the negative lead to ground. Cut the unground leads of C1 and C2 to a length 1/8 inch above the circuit board.

9) Preform 79L05 negative voltage regulator A1 by first cutting the center lead (Vin) to 1/4 inch length. Bend the ground lead horizontally outwards about 1/4 inch down from the case. Bend the other lead (Vout) horizontally outward at the case. Position the center lead of A1 over the negative lead of C1 (the lead not soldered to ground) and the ground lead towards the board's top edge. Carefully solder the center lead to C1. Now solder the ground lead of A1 to ground. With the ground lead holding A1 in position, solder a two inch connecting wire to the Vin-C1 junction. This is the -12 volt input. Check this solder joint for shorts to ground. Since U1 is a $20.00 chip, I applied -12 volts to A1's input wire and checked for -5 volts at the output lead before soldering the Vout lead to U1. When you have the regulator A1 working properly, bend the Vout lead around to pin 20 of U1 and solder them together. Ensure bypass capacitor C4's lead remains soldered to pin 20.

10) Preform 0.1 uF bypass capacitor C3 by cutting both leads to a length of 1/4 inch and then bending one lead straight out horizontally. Position C3 laying down against the ground foil with the unbent lead over and parallel to pin 17 of U1, and solder them together. Press the other lead of C3 against the ground foil, and solder it to ground.

11) Preform 78L05 positive voltage regulator A2 by cutting the Vin lead to 1/4 inch length. As in Step 9, bend the ground lead (center) out horizontally towards the flat face of A2, 1/4 inch down from the case, and the Vout lead horizontally out at the case. Position the Vin lead over the positive lead of C2 and solder. Now solder the ground lead to the ground foil. Again solder a two-inch connecting wire to the Vin-C2 junction and then check for shorts to ground. Apply +12 volts to Vin and check for +5 volts output from A2. Bend the Vout lead against pin 17 of U1 and C3 and solder.

12) Preform 10K resistor R2 by bending one lead 90 degrees at the resistor base to form an "L." Place 10K resistor R1 parallel beside and against R2, and bend R1's lead around the bent lead of R2. Solder the resistors together, and trim R1's lead off. Now cut the other unconnected leads of R1 and R2 to a length of 1/4 inch. Bend a small half loop on the end of each lead, point-

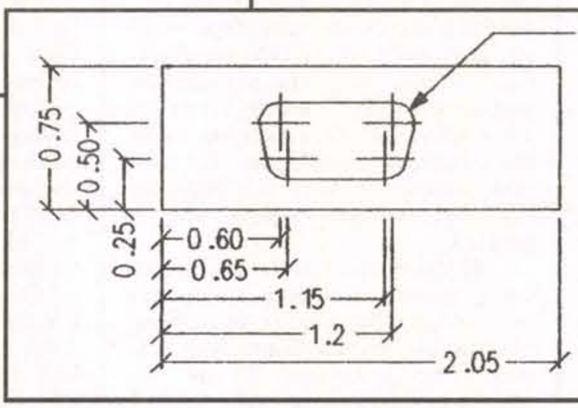


FIGURE 7
ENCLOSURE SIDE LAYOUT.

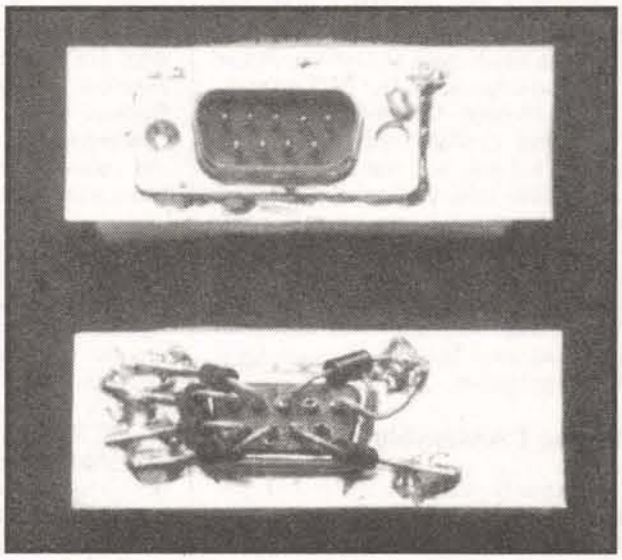
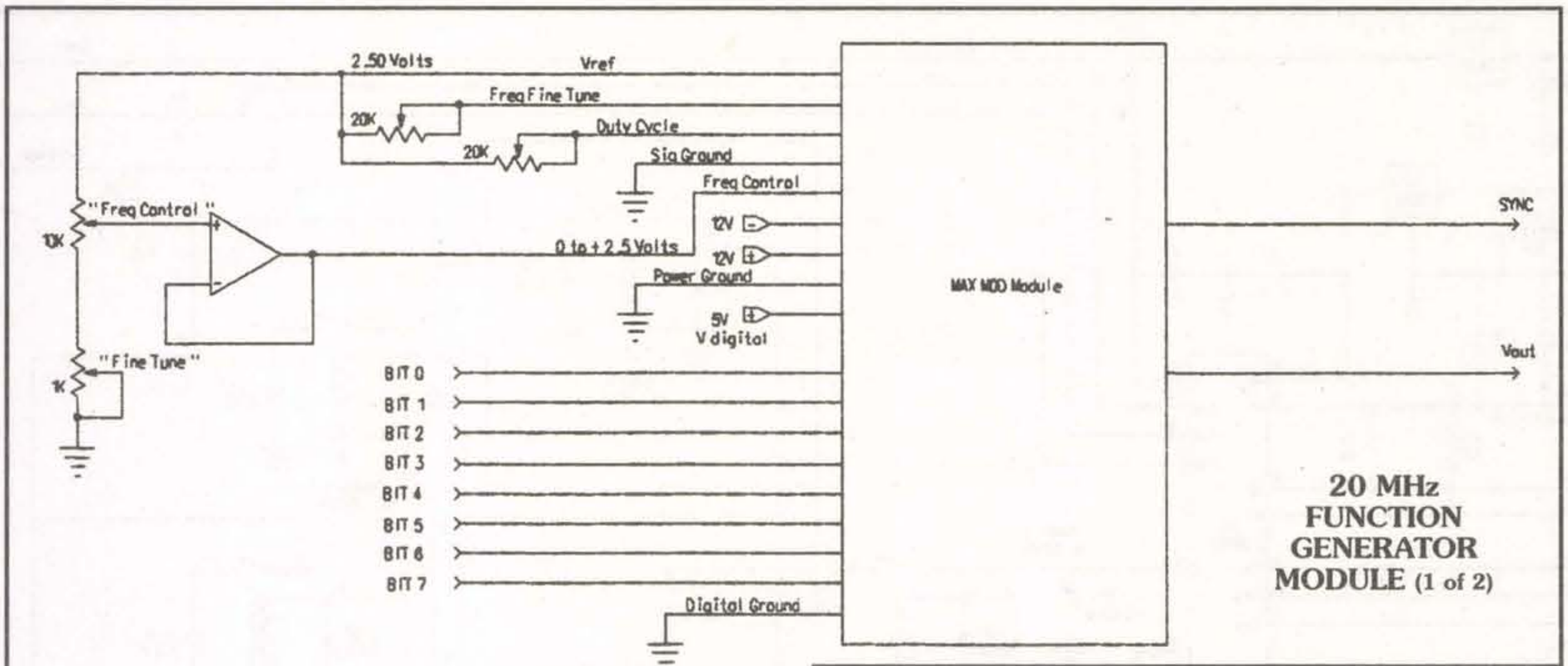


FIGURE 8
CONNECTORS SOLDERED TO END PLATES. TOP IS P1, WHILE BOTTOM IS REAR VIEW OF J1, SHOWING PLACEMENT OF DIODES.



20 MHz FUNCTION GENERATOR MODULE (1 of 2)

Last Used	Spares	Not Used
A3	None	None
C15		
D6		
J1		
K6		
P1		
R4		
U1		

TRUTH TABLES

Wave form	A0	A1
Sine	X	1
Square	0	0
Triangle	1	0

Control Bit #	1	2	3	4	5	6
1-20 MHz	0	0	0	0	0	0
.1-2 MHz	1	0	0	0	0	0
10-200 KHz	1	1	0	0	0	0
1-20 KHz	1	0	1	0	0	0
0.1-2 KHz	1	0	0	1	0	0
10-200 Hz	1	0	0	0	1	0
1-20 Hz	1	0	0	0	0	1

(Frequency Range)

ing outward and opposite to each other. Bend pins 3 and 4 of U1 up almost vertically. Place the R1-R2 assembly across U1's top with the half loops hooking on pins 3 and 4 and the bent lead of R2 towards the rear of U1. Solder R2 to pin 3 and R1 to pin 4. Bend pin 16 of U1 straight up until it contacts the leads of R1 and R2. Solder the connection. Leave the lead for R1/R2 as is for now, to be used to connect the digital +5 volt supply using a test lead. Do not trim pins 3 and 4 of U1, as wires will be connected later.

13) Trim both leads of R3 to 1/4 inch length. Solder a two-inch connecting wire to one lead of R3 (5620 ohm, 1%). Solder the other lead of R3 to pin 10 of U1. Resistor R3 is parallel to the board and perpendicular to the side of U1.

14) Trim one lead of 51-ohm resistor R4 to 1/4 inch length. Solder the short lead of R4 to pin 19 of U1. Resistor R4 is parallel to the board and perpendicular to the side of U1. Leave the free lead of R4 as is for now; it is the output of U1.

15) Solder a two-inch connecting wire to pin 7 of U1 and another connecting wire to pin 8. These are the control inputs to frequency fine tuning and wave form symmetry.

16) Solder a connecting wire to pin 3 of relay K1. Check for a short to ground. The resistance from pin 3 to ground for all the relays is about 500 ohms.

17) The electrical testing of phase I construction requires the temporary installation of a 12K resistor. Solder one lead of this 12K resistor to the ground plane of the circuit board. Solder the wire from pin 8 of U1 to the other lead of this 12K resistor. The connecting wire from pin 7 must be soldered to the ground side of the 12K resistor.

Phase I Testing

Phase I is the minimum construction required for the MAX MOD to operate. Your MAX MOD should look like Figure 2. Before additional construction clutters up the work area and makes rework of the module more difficult, you should test the circuit to verify its operation.

This test is a bench test requiring an oscilloscope, a split voltage power supply with approximately 12 volts output, a power supply with 5 volts output, and a variable voltage supply with 0 to 2.5 volts output. If you use a variable resistor for this last voltage, you MUST buffer it with an op-amp stage as a source follower (unity gain, noninverting). Connecting the wiper arm of a variable resistor directly to the frequency control will give erratic frequency results. A frequency counter would be helpful but is not essential for this test.

1) Connect the power supplies as follows:

a) The +12 volts to the free lead of A2.

b) The -12 volts to the free lead of A1.

c) The +5 volts to the free lead wire of R1 and 2.

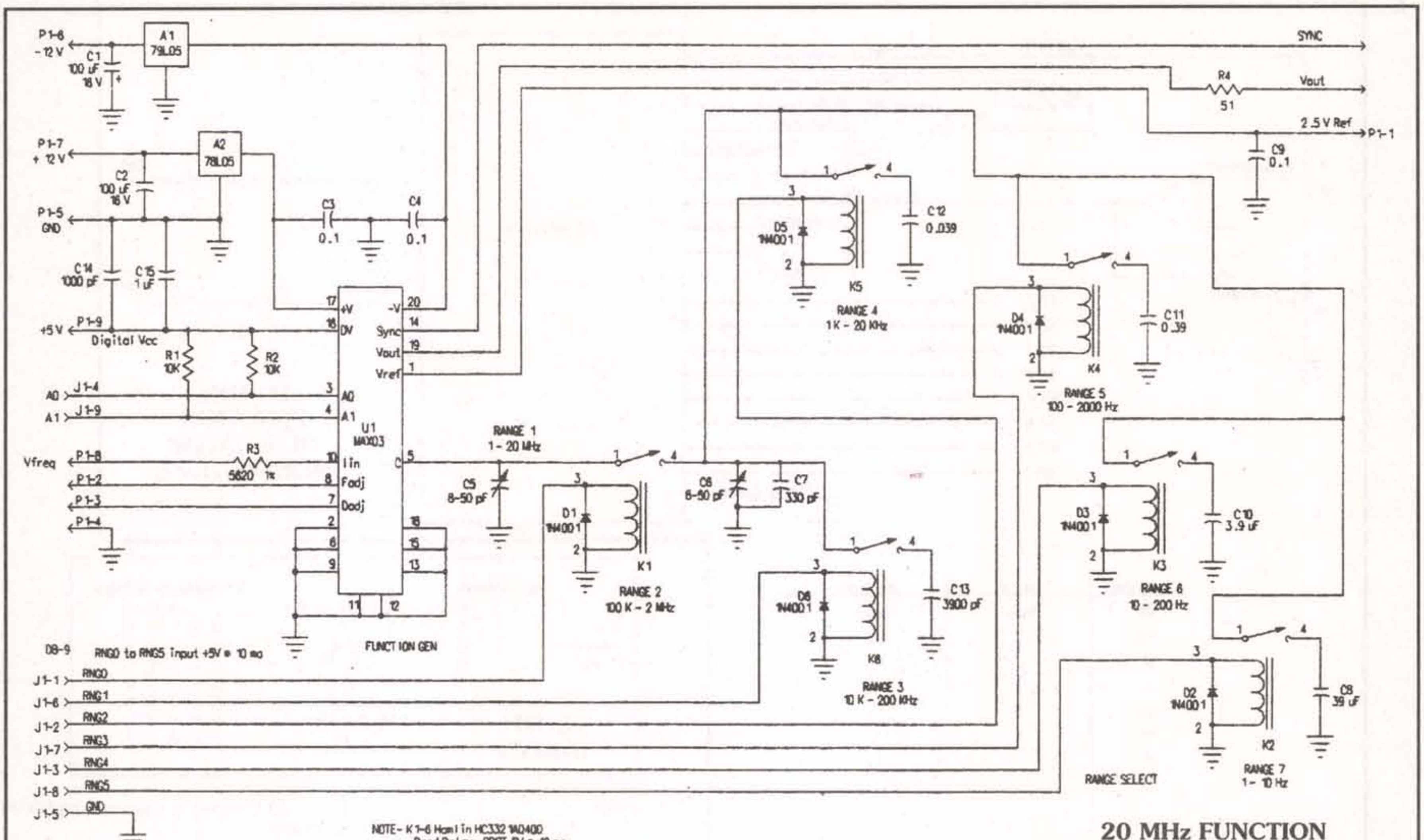
d) The positive side of the variable voltage source to the wire lead of R3.

e) All ground leads to the ground plane of the circuit board.

2) First turn the split power supply (±12 volts) on and check the current from each leg. You should be pulling significantly less than 100 mA. If more, turn power off and find the cause. Look first for any shorts to ground.

3) Now turn the +5 volts supply on. Again, you should be pulling significantly less than 100 mA. If more, turn power off and find the cause. Look first for any shorts to ground.

4) Connect the probe of the oscilloscope to MAX MODs output, which is the free lead of R4. There should be



20 MHz FUNCTION GENERATOR MODULE (2 of 2)

a sinewave signal about 2 volts peak-to-peak. If using a dual trace oscilloscope, connect the other probe to pin 14 of U1. There will be a squarewave at pin 14 that is TTL (0 to 5 volts) and is synchronized to the sinewave output. Adjust the variable voltage full range of 0 to 2.5 volts. The frequency of the output should vary by a factor of 100. Now set the variable voltage to 2.5 volts. Adjust capacitor C5 for an output of 20 MHz. Adjust the variable voltage to 0 volts. The output frequency should drop to about 2 MHz.

NOTE: The sinewave output will appear with noise since the +5 volt bypass capacitor has not yet been installed.

5) Using a jumper clip lead, connect the wire from pin 3 of K1 to the +5 volt supply. The frequency output should drop by a factor of 10. Adjust capacitor C6, and ensure the output frequency changes. At this time, you cannot set the frequency for this range, since capacitor C7 has not been installed. Disconnect the jumper clip lead.

6) Connect a jumper clip lead from pin 4 of U1 to ground. The output wave form should change from a sinewave to a triangle. The wave form should not change in frequency or amplitude. Adjust the variable voltage to 2.5 volts. The wave form should still be a triangle.

7) Connect a second jumper clip lead from pin 3 of U1 to ground. The output wave form should now be a squarewave. This completes the phase I testing.

Phase II Assembly

With the MAX MOD operating correctly, you are ready to continue assembly. Phase II assembly is the installation of the range capacitors, reed relays, and connectors for digital and analog control. Refer to Figure 6.

1) Install relays K2 through 6 by inserting their leads through the holes in the board, towards the copper foil side, the same as for K1. Solder pin 2 of each relay to the ground plane. Refer to Figure 3.

Install the remaining range capacitors in the order specified below. These capacitors will require a common bus

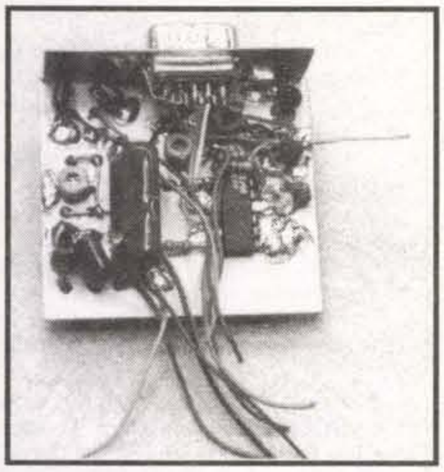


FIGURE 9
INSTALLATION OF P1 SIDE PANEL. NOTE THAT CONNECTOR P1 IS CLOSE TO U1. SIDE PANEL IS SOLDERED ON OUTSIDE EDGE ONLY.

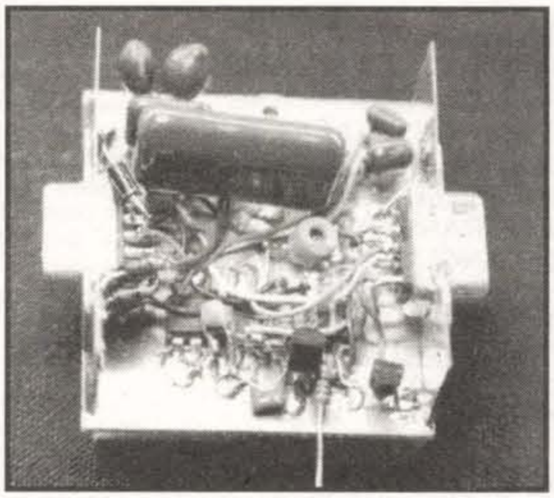


FIGURE 10
BOTH SIDE PANELS WITH CONNECTORS INSTALLED WITH THEIR INTERCONNECTIONS WIRED. NOTE THAT WIRES ARE POSITIONED AGAINST GROUND PLANE OF BOARD.

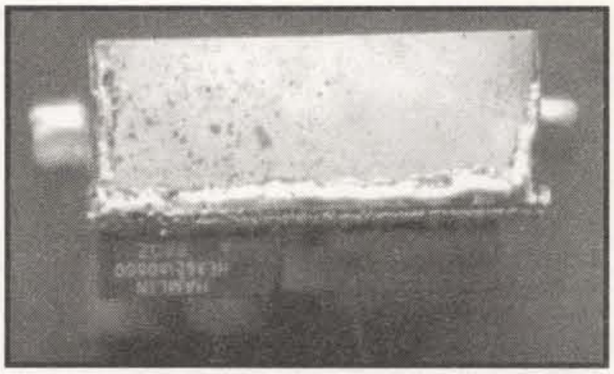


FIGURE 11
PLAIN SIDE PLATE INSTALLED. NOTE THAT PLATE CORNERS ARE NOT SOLDERED FOR THE TOP 1/4 INCH.

for the input to their relays (pin 1). Continually check your work as you proceed for any shorts to ground.

2) Using two segments of bare AWG #20 solid bus wire, connect pin 1 of relays K2 through 6 and pin 4 of K1. Position one segment of bus wire between pin 1 of K2 to pin 1 of K3, and solder the bus wire to pin 1 of K2. Now solder the bus wire to pin 1 of K3 and then trim the bus wire. Solder the junction of K5, pin 1, and the bus wire. You may need a "clip on" heatsink to prevent the first two solder joints from remelting. Check the bus wire for any shorts to ground before proceeding.

3) Again use AWG 20 solid bus wire, and start by bending it into an "L" shape that touches pin 1 of relay K6. Place a 'clip on' heatsink onto the junction of pin 1, K6, and the bus wire installed in Step 2. Start by soldering the bus wire to pin 1 of K4. Now bend the free end of the bus wire up against C6 and the pin 4-K1 junction. Solder the bus wire to this junction, and then solder this bus wire to the first bus wire in Step 2. Trim the bus wire flush. Now solder the bus wire to pin 1 of K4 and then pin 4 of K1. Again, check the bus wire for any shorts to ground before proceeding.

4) Prepare five connecting wires as described in the beginning of the Phase I assembly section. Solder a connecting wire to pin 3 of relay K3. Continue soldering connecting wires to pin 3 of K4, then K5, followed by K2, and finally K6. Check each connecting wire for shorts to ground. With no shorts to ground, you should read about 500 ohms. Test the solder joints of each relay to the wire bus by energizing each relay with +5 volts via its connecting wires, and test for continuity from the bus wire to pin 4 of the energized relay.

5) Preform 3900 pF capacitor C13 by trimming one lead to 1/8 inch length and the other lead to 3/16 inch. Bend the 3/16 inch lead at its middle, 90 degrees out from the end of the capacitor. Refer to Figure 5, and position C13 with its 1/8 inch lead on pin 4 of relay K6. Carefully solder the 1/8 inch lead to pin 4 of K6. Now solder the bent lead to the ground plane of the circuit board. Check that the solder joint to pin 4 of K6 is mechanically sound, and then check for a short to ground.

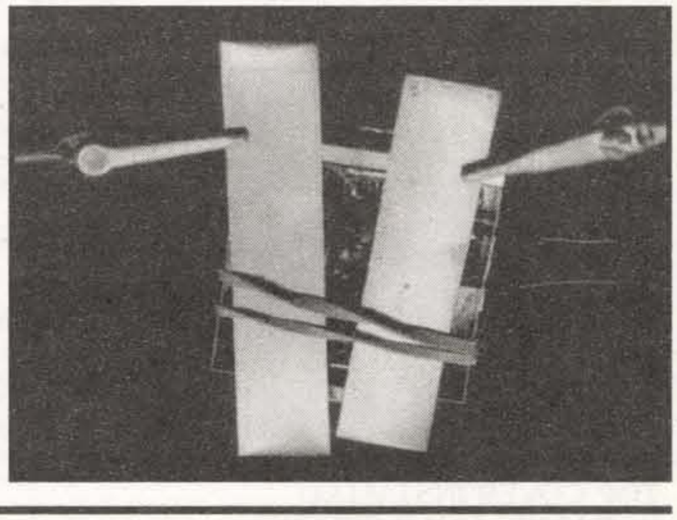
6) Preform 0.039 uF capacitor C12 the same as in Step 4. Install capacitor C12 to pin 4 of relay K5, as shown in Figure 5.

7) Preform 0.39 uF capacitor C11 the same as in Step 4. Install capacitor C11 to pin 4 of relay K4, as shown in Figure 5.

8) Preform 3.9 uF capacitor C10 the same as in Step 4. Install capacitor C10 to pin 4 of relay K3, as shown in Figure 5. Due to the size of C10, you must take care that the top of C10 is less than 0.75 inches from the circuit board. This precaution is required to ensure the case top will fit. Install capacitor C10 to pin 4 of relay K3, as shown in Figure 5.

9) Since the range capacitors must be non-polarized capacitors and C8 is a large value capacitor, C8 will be made into a non-polar capacitor by using two polarized capacitors in series. The positive leads of a 100 uF tantalum and a 68 uF tantalum are twisted closely together, and soldered. These leads are trimmed to about 1/8 inch from the capacitor's bodies. Since the two capacitors are in series, the total capacitance is about 40 uF which is close to the required 39 uF value of C8. Since this range is so low (1-20 Hz), this inaccuracy should not cause problems. Preform this composite capacitor by trimming one lead to 1/4 inch and the

FIGURE 12
INSTALLING ANGLE BRASS TO FORM TOP LIP. STRIPS OF BRASS BRIDGE ACROSS SHIELD BOX OF MAX MOD TO SET THE HEIGHT FOR COVER. ALLIGATOR CLIPS HOLD ANGLE BRASS IN POSITION FOR SOLDERING.



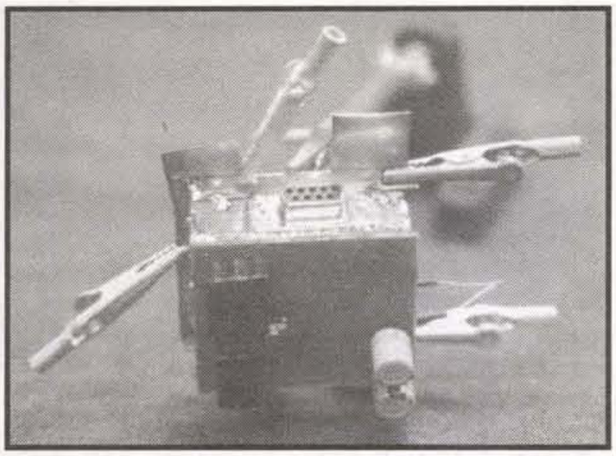


FIGURE 13
SECOND ANGLE BRASS IS INSTALLED, AGAIN USING BRASS STRIPS TO SET THE TOP LEVEL. NOTE IN UPPER LEFT CORNER, HOW SIDE ANGLE BRASS OVERLAPS FRONT ANGLE BRASS. RIGHT END OF FRONT ANGLE BRASS EXTENDS OUT TO OVERLAP OTHER SIDE WHEN IT IS INSTALLED.

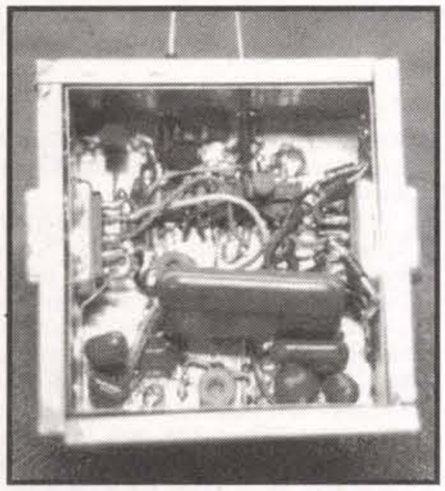


FIGURE 14
TOP LIP COMPLETED. NOTE HOW EACH BRASS ANGLE OVERLAPS ANOTHER AT EACH CORNER. MAX MOD IS NOW READY FOR TOP COVER.

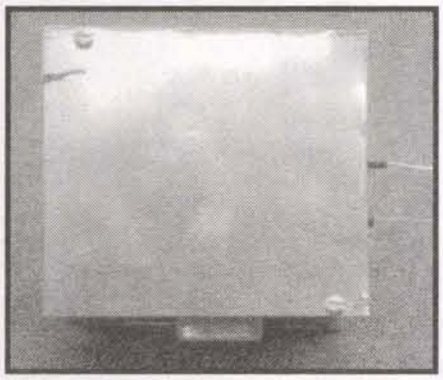


FIGURE 15
TOP COVER INSTALLED WITH TWO HOLD SCREWS, PLACED ON OPPOSITE CORNERS TO HOLD COVER STEADY WHILE DRILLING REMAINING HOLES. NOTE COVER POSITION REFERENCE MARKING ON UPPER LEFT CORNER.

other to 1/2 inch. Bend the 1/2 inch lead at its middle, 90 degrees out from the end of the composite capacitor. Refer to Figure 5, and position C8 with its 1/4 inch lead on pin 4 of relay K2. Carefully solder the 1/4 inch lead to pin 4 of K2. Now solder the bent lead to the ground plane of the circuit board. Check that the solder joint to pin 4 of K2 is mechanically sound, and then check for a short to ground.

10) Preform 330 pF capacitor C7 by cutting both leads to 1/4 inch in length. Bend both leads up 90 degrees straight out from the capacitor. Position C7 on its side with one lead on top of the bus wire between pjn 1 of K4 and K6, and solder together. Solder the other lead to the ground plane, and then check the bus wire for shorts to ground.

11) Bend both leads of 1.0 uF capacitor C15, 90 degrees up and straight out from the capacitor. Place 1000 pF capacitor C14 against the side of C15, with its leads next to C15's leads. Take each lead of C14 and wrap it once around the adjacent lead of C15. Solder the leads of C14 to C15, and trim C14's leads flush with C15's leads. Trim both of C15's leads to 1/4 inch length. Place C14-15 parallel to U1, with one lead against the junction of U1-pin 16, R1, and R2 and solder. Position the other lead of C14-15 against the board's ground plane and solder. Ensure that neither lead is shorting against any other pins of U1.

12) Prepare three connecting wires as described in the Phase I section. Solder one end of a connection wire to:

- The junction of U1-16, R1, R2, C14, and C15, +5 volts input.
- The junction of U1-3 and R2, A0 input for wave form select.
- The junction of U1-4 and R1, A1 input for wave form select.

This concludes Phase II construction.

Phase II Testing

Test the Phase II module in the same manner as for Phase I, however, use the connecting wires to connect power and control inputs. Jumper wires can be used to activate each range select relay. Remember to activate relay K1 first and leave active, as you energize other relays. Energizing each range relay in order will cause the frequency to decrease a decade.

When you have completed all testing, remove the 12K ohm resistor soldered to the connecting wire from pin 7-8 of U1 and from the ground plane. Save the 12K ohm resistor for Phase III testing.

Phase III Construction

Before you continue any electrical assembly, you must fabricate two side panels from brass sheets. Refer to Figure 7, Enclosure Side Layout, and cut two blank side panels from 0.75 inch wide, 0.016 inch thick brass stock. Both side panels are 2.05 inches long. Layout and mark the center positions for the four corner holes. Drill the four holes using a 7/32 inch drill bit, and then complete the cutout by cutting between the holes. I used a Dremel tool with a No. 409 cutoff wheel. Use a file to smooth out any rough spots and remove burrs. The DB-9 connectors are soldered to the brass side panels. To facilitate the soldering, you should wash the brass with steel wool just prior to soldering.

1) Position one brass side panel on the side of MAX MOD's circuit board adjacent to the top of U1 (near pin 1 and pin 20). There are four possible ways for the cutout of connector P1 to be orientated. Position the brass side panel so that the cutout is closest to U1, and the short side of the cutout is towards the circuit board. This position establishes the inside and outside surfaces of the panel. Place connector P1, DB-9 Male connector, on the outside surface of the side panel; that is, with the metal flange of P1 against the outside surface of the side panel. Solder P1 to the side panel by first tack soldering one corner and then the opposite diagonal corner. When connector P1 is correctly positioned against the side panel, solder a continuous bead around the parameter of P1. Set the P1 assembly aside for now.

2) Position the second brass side panel on the opposite side of MAX MOD. Again the side panel should be positioned with its cutout nearest U1, and the short side of the cutout nearest the circuit board. Place connector J1, DB-9 Female connector, on the outside surface of the side panel; that is, with the metal flange of J1 against the outside surface of the side panel. Solder J1 to the side panel by first tack soldering one corner and then the opposite diagonal corner. When connector J1 is correctly positioned against the side panel, solder a continuous bead around the parameter of J1.

3) Diodes D1 through 6 (1N4001) are installed directly to the J1 assembly. Refer to Figure 8. The cathode lead of all the diodes is installed in the pin cup of J1, and the anode lead is soldered to the brass side panel. Trim the cathode lead (banded end) of each diode except D3 to 3/8 inch and solder to its appropriate pin cup of J1. Bend each diode over into position and trim the anode lead so that 1/8 inch of the lead is against the brass side panel, and then solder it in place. Note that the anode lead of D3 is bent back and soldered to pin 5 to connect it to ground. Install the diodes in the following order.

- D1 cathode to J1-1 and anode to left side of J1.
- D6 cathode to J1-6 and anode to left side of J1.
- D5 cathode to J1-2 and anode to left top side of J1.
- D4 cathode to J1-7 and anode to left bottom side of J1.
- D2 cathode to J1-8 and anode to right bottom corner side of J1.

D3 cathode to J1-3 and anode to right top corner side and looped back to J1-5.

4) Install the P1 side panel onto the MAX MOD circuit board. Position the side panel along the edge of the circuit board, with the back of P1 pointed inwards towards U1, pins 1 and 20. See Figure 9. The side panel should be set back about 0.05 inches from the edge of the circuit board. Ensure the side panel is perpendicular to the circuit board, and tack solder one corner. Due to the heat build-up, you will need to clamp hold the side panel using something like a third hand holder from RadioShack (P/N 64-2063). Check that the panel is still correctly positioned. At this time, you can still bend the side panel to reposition it. With the side panel perpendicular and parallel to the side of the circuit board, tack solder the other corner. Now you can solder a continuous seam along the bottom of the side panel. Solder only the outside edge of the side panel.

5) Install the J1 side panel in the same manner as the P1 side panel. Ensure that the back for J1 is positioned nearest pins 10 and 11 of U1.

6) In this step, the wires are connected to J1 and P1. Connect the wires in the order specified below. For each wire, route it to its pin on the connector, and position the wire against the ground plane of the circuit board. Cut the excess length off and strip 1/8 inch off the wire, and tin the wire prior to soldering it to its pin. For those wires that connect to pins of J1 and that also have a diode, bend the bare portion of the wire into a hook, and solder it to the cathode lead of the wire. Figure 10 shows the completed wiring of J1 and P1. The order of assembly is:

- For the first two wires, use bare bus wire, AWG #24, cut each to a length to fit.
- Solder bus wire, AWG #24 from the ground of the side panel to pins 4 and 5 of P1.
- Solder bus wire from pin 1 of U1 to pin 1 of P1. Position this wire around pin 6 of P1. Ensure it does not short to ground.

The remaining wires are connec-

TABLE 1

Connection	Test Connector	Final destination
+12 Volts	Pin 7, P1	Input pin of A2, positive voltage regulator
-12 Volts	Pin 6, P1	Input pin of A1, negative voltage regulator
+5 Volts	Pin 9, P1	Pin 16 of U1, digital 5 volt supply
Ground	Pin 4, P1	Ground plane of circuit board
Ground	Pin 5, P1	Ground plane of circuit board
12K ohm	Pin 2, P1	Pin 8 of U1, Freq Adjust, other end 12K to ground
Ground	Pin 3, P1	Pin 7 of U1, Duty Adjust, connect to ground for test
VCO (0-2.5V)	Pin 8, P1	Pin 10 of U1 through R3, measure resistance of R3
Voltmeter	Pin 1, P1	Pin 1 of U1, measure 2.5 DC volts output from U1
+5 Volts	Pin 1, J1	Pin 3 of Relay K1, relay coil, other side to ground
+5 Volts	Pin 6, J1	Pin 3 of Relay K6, relay coil, other side to ground
+5 Volts	Pin 2, J1	Pin 3 of Relay K5, relay coil, other side to ground
+5 Volts	Pin 7, J1	Pin 3 of Relay K4, relay coil, other side to ground
+5 Volts	Pin 3, J1	Pin 3 of Relay K3, relay coil, other side to ground
+5 Volts	Pin 8, J1	Pin 3 of Relay K2, relay coil, other side to ground
Ground	Pin 5, J1	Ground plane of circuit board
Ground	Pin 4, J1	Pin 3 of U1, pull down for A0, wave form select
Ground	Pin 9, J1	Pin 4 of U1, pull down for A1, wave form select

tion wires that were previously installed.

• Solder the wire from pin 16, U1 to pin 9 of P1.

• Solder the wire from R3 to pin 8 of P1.

• Solder the wire from the input of A2, to pin 7 of P1.

• Solder the wire from the input of A1, to pin 6 of P1.

• Solder the wire from pin 7 of U1, to pin 3 of P1.

• Solder the wire from pin 8 of U1, to pin 2 of P1.

• Visually check the pins of connector P1 for any solder shorts or bridges. Correct these before proceeding to connector J1.

• Solder the wire from pin 4 of U1, to pin 9 of J1.

• Solder the wire from relay K2, to pin 8 of J1.

• Solder the wire from relay K4, to pin 7 of J1.

• Solder the wire from pin 3 of U1, to pin 4 of J1.

• Solder the wire from relay K3, to pin 3 of J1.

• Solder the wire from relay K5, to pin 2 of J1.

• Solder the wire from relay K1, to pin 1 of J1.

• Solder the wire from relay K6, to pin 6 of J1.

• Again, visually check the pins of connector J1 for any solder shorts or bridges before proceeding to Phase III testing and calibration.

Phase III Testing

The Phase III testing of MAX MOD is the same as for Phase II, except all connections are made through connectors J1 and P1. To facilitate testing, I made two mating DB-9 connectors with four-inch pigtail leads soldered to each pin. To avoid confusion, I used the same color coding of wires that I used for J1 and P1.

Before applying any power or voltage, you may want to do a continuity test of each lead to ensure it really goes where you think is goes. To facilitate continuity checking, Table 1 has the final destination of each pig tail wire. Connect the corresponding test connector to J1 and P1. Attach test leads to the appropriate pig tails, as designated by the Connection column in Table 1. Note that the pin numbers in the Test Connector column refer to the pins on the test connector and are the same as the pin numbers on the connectors themselves.

As in Phase II testing, use jumper leads to energize relays and to select wave form types. Do not forget to connect the 12K ohm resistor from pin 3 of P1 to ground and ground pin 2 of P1; otherwise, the circuit will not work.

Final Assembly

The final assembly consists mostly of the shielding's mechanical assembly. The electrical testing will consist of verifying no shorts have occurred during assembly of the shielding. There are two methods for making and installing the top cover. You can cut a brass top that will just fit the sides, and then tack solder it in place. This means desoldering the top each time you need access to MAX MOD's interior. Or you can get really fancy, and make a top that is secured by screws for easy removal. I will describe this method. Leaving the instruments connected to the pig leads of the test connectors, disconnect your MAX MOD from your test set-up. The final assembly should require little time, and you will be ready for retesting.

The materials and tools described in this section are available at most hobby stores, and some hardware stores. You will require the listed tools and supplies for the screw cover shielding version in Table 2. The vendors Walthers and K & S Engineering are very common in hobby stores, particularly those dealing in model railroads.

1) Cut a AWG #26 bare bus wire to 1-1/2 inches, and solder to pin 14 of U1. Solder this wire perpendicular to U1's side and parallel to the circuit board. This lead is for the synchronous TTL squarewave output.

2) Cut two lengths of 1/8 inch diameter heat shrink tubing, each 3/4 inch long. Slide one tubing onto the wire and resistor of U1, pin 19, and the other on the wire to U1, pin 14. Heat the tubing, and shrink to a tight fit. This forms the output feed throughs for passing through the side panel.

3) Measure and cut the side panel to fit between the J1 and P1 side panels, of the side nearest the relays. Cut this side from 3/4 inch wide, 0.016 inch thick brass stock. Tack solder this side panel to both of the other side panels. Now solder a continuous seam on the bottom outside edge to the circuit board. Complete the soldering of the two side joints, but do not solder the last 1/4 inch of the top corners, to avoid interfering with the angle strips installed later. Refer to Figure 11.

4) Measure and cut a second side panel to fit the remaining side adjacent to U1, from the same brass stock as in Step 2. Before soldering, mark the positions where the output wires will pass through. Since the wires are flexible, positioning of these holes is not critical. Drill both holes using a 3/32 drill bit. Now position the side panel with the output wires passing through their respective holes. Tack solder this side panel to the other adjacent side panels. Now solder a continuous seam on the bottom outside edge to the circuit board. Complete the soldering of the two side joints.

5) The following angle strips are used to form a mating surface for the top. Therefore, you should take care in their positioning before soldering. Each length of brass angle should be longer than the side by one width of the brass angle. This provides an overlap at each corner of the shielding. Start with a side having a DB-9 connector and measure the angle brass to the length of that side, and then add the width of the angle brass. Position this brass with one leg against the side of the shield, and the other leg up and flush with the top of the shield case. To ensure the brass angle is flush with the top, use two brass strips laying across the side panels, the angle brass clipped to these two brass strips using alligator clips. As shown in Figure 12, one end of the angle brass should be flush with the corner of the shield with the other end extending out past the opposite corner of the shield. Tack solder the leg of the angle brass to the side panel, about every half inch.

6) Going to the side that the brass angle extends past, measure a second length of angle brass that fits against the first brass angle and extends the width of the angle brass past the next side panel. Again, solder the angle brass part to the side panel, the same as in Step 4. Use the two brass strips and alligator clips to carefully position the angle flush with the top of the shielding case as shown in Figure 13. Solder the two angle brass strips together from the BOTTOM side only.

7) Continue measuring and installing the remaining two angle brass sides using the same procedure as described above. When you are finished, you will have a continuous 1/8 inch flange around the top edge of the shield. See Figure 14. The top cover will rest on this flange.

8) Fabricate the top cover from a sheet of brass stock, 0.015 inch thick (K & S part number 252, 4 x 10 inches) by cutting a rectangular section that matches the outer edges of the flanges. Place the MAX MOD upside down on the sheet of brass, and mark its edges. With the top positioned over the flange, mark an alignment mark on one side of MAX MOD and the top using a magic marker. This alignment mark will allow you to replace the top in the same position each time.

9) In these next steps, you will drill the holes for holding the top on with screws. The screw holes should be centered along the length of the flanges. Position the top cover on the flanges with their alignment marks matching. Again, use alligator clips to hold the top in position. Drill the first hole using a #50 bit, on any of the four corners. Refer to Figure 15. Remember, center the hole on the flanges. Remove the top cover, and tap the flange using a #2 self-tapping screw (Walthers part number 947-1189). Enlarge the hole on the top cover by redrilling the hole with a #42 bit. This hole will allow the screw to pass through the top cover, and screw into the flange.

10) Replace the top cover, with the alignment marks matching, and install a #2 x 3/16 self-tapping screw. Now drill a second #50 hole on the diagonally opposite corner to the first screw. Again remove the top cover, and tap the hole with the #2 self-tapping screw. Then, enlarge the hole in the top cover with the #42 bit.

11) Again replace the top cover and install two #2 x 3/16 screws in the holes. The top cover is now locked in position. Using the #50 bit, drill the remaining holes around the perimeter of the top (Figure 16), each hole spaced approximately 1/2 inch. Remove the top cover and redrill the holes in the cover with the #42 bit. Tap the remaining holes of the shield case with the #2 self-tapping screw. Do not replace the top cover until the MAX MOD has been calibrated. Visually check the interior of your MAX MOD for any shorts or metal particles.

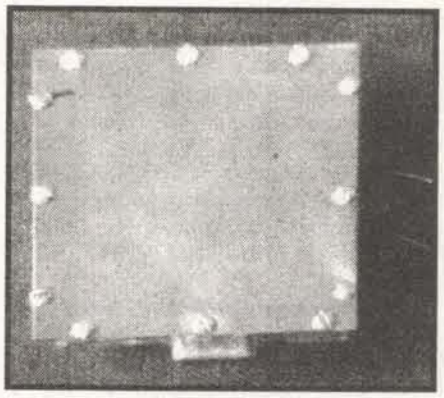


FIGURE 16
TOP COVER COMPLETED.

Item	Vendor	Part Number
#2 x 3/16 self-tapping screws	Walthers	947-1189
#50 (0.0700 inch dia) drill bit	Mascot	50
#42 (0.0935 inch dia) drill bit	Mascot	42
1/8 x 1/8 inch brass angle	K & S Engineering	171
3/4 x 0.016 inch brass strip	K & S Engineering	233
4 x 10 x 0.015 inch brass sheet	K & S Engineering	252

TABLE 2

Calibration

Reconnect your MAX MOD to the test set-up via the test connectors to J1 and P1. If you are using a frequency counter, connect it to the output wire from resistor R4. If using an oscilloscope, then you will need to measure the wave form period, and calculate the frequency by:

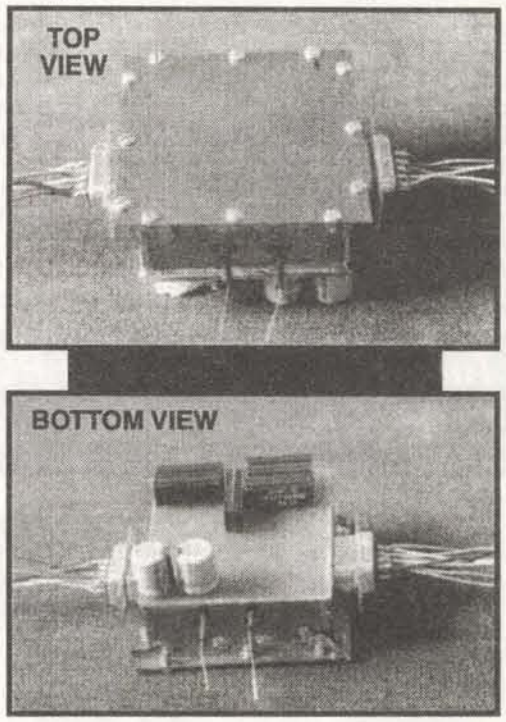


FIGURE 17
COMPLETED MAX MOD, READY FOR YOUR PROJECT.

Frequency (Hz) = 1 / Period (Seconds)

Apply power to the unit, and check that the current for each power supply is under 100 mA. Remove all of the relays from their drive voltage. The unit should be selected for the highest frequency range.

1) Connect a voltmeter to the frequency voltage input, pin 8 of P1. Monitor the DC voltage with respect to ground. Set the frequency control voltage to 1.00 volts. Adjust trimmer capacitor C5 for a frequency output of about 8 MHz. Increase the frequency control voltage to 2.50 volts. The output frequency should be at least 20 MHz. If not, adjust capacitor C5 until

you have 20.00 MHz.

2) Now, power relay K1 with +5 volts through pin 1 of J1. Adjust the frequency control voltage to 1.00 volts. This selects the second frequency range. Adjust trimmer capacitor C6 for a frequency output of 800 KHz. Adjust the frequency control voltage to 2.50 volts. The frequency should then be 2 MHz. If less than 2 MHz, adjust C6 for 2.00 MHz.

3) Power relays K2 through K6 in descending order, and check that the frequency drops by a decade. Because of the wide tolerances of C8, the frequency of range 7 can vary significantly from the decade value expected.

4) This completes the calibration. Power the unit down, and remove it from the test set-up. Replace the cover and install all the #2 screws. Your MAX MOD is now ready for use. Figure 17 shows the MAX MOD top and bottom views with connecting control cables.

Using MAX MOD

While doing MAX MOD's electrical test during construction, you have seen how easy it is to use your MAX MOD. A minimum system requires only the 0 to 2.5 volts for frequency control and some switches to select the frequency range. This makes it ideal to use with a computer having a D/A port and some buffered digital I/O port. The D/A's output is scaled to 0 to 2.5 volts, and the outputs of the digital I/O must buffer to source 10 milliamps.

Software may then be written to sweep the frequency over many decades, controlling the rate of sweep with simple delay loops. As the frequency approaches the high end of one decade, the range capacitors are switched to the next decade and the D/A sweep voltage reset to zero again, all by using software.

If manual operation is desired, then the buffered 0 to 2.5 volts may be used with the internal 2.5-volt reference across a potentiometer for the input to the op amp. A two pole, seven-position switch is used to control the range relays. One pole controls relay K1, while the other pole selects relays K2 through K6. Position 1 leaves all relays unenergized. Position 2 only energizes relay K1, while the remaining positions always energize relay K1 and sequentially relays K2 through K6.

Although the output of MAX MOD is 50 ohms, a buffer amplifier such as the MAX 442 should be used. A variable switched 50-ohm attenuator may then be inserted between MAX MOD and the buffer amplifier for range selection. A 1 Kohm potentiometer can then be used for the buffer amplifier's input to allow continuous variation of the output.

The variations for using MAX MOD is limited only by your imagination. Using computers, you can build or set-up many varied and unique instruments. The module may also be used in conjunction with phase lock loops and crystal references to give highly stable sinewave generators.

Note that when MAX MOD is built per this article, the high frequency sinewaves have a glitch on their peaks. This is from the synchronous squarewave at U1, pin 14. If you want a cleaner sinewave and don't need the synchronous squarewave, then connect U1, pin 16, digital power supply to ground, and reroute the +5 volts to R1 and R2. **NV**

PARTS LIST

REF. DESG.	QTY.	NOMENCLATURE	PART #
A1	1	78L05, 5 volt, positive voltage reg, 100 mA, TO-92	
A2	1	79L05, 5 volt, negative voltage reg, 100 mA, TO-92	
C1,2	2	100 uF, electrolytic capacitor, 16 volt, Ld Sp=0.2 in radial	P6620
C3,4,9	3	0.1 uF bypass cap, monolithic ceramic, 25V, Ld Sp=0.2 in	P4923
C5,6	2	8-50 pF trimmer capacitor, top adj, 5mm	SG1006
C7	1	330 pF polypropylene capacitor, 5%	P3331
C8	1	68 uF tantalum capacitor, 10 volts, 20%	P2031
	1	100 uF tantalum capacitor, 10 volts, 20%	P2032
C10	1	3.9 uF metal poly capacitor, 100 volts, 10%	E1395
C11	1	.039 uF metal film, 5%	P4670
C12	1	0.039 uF polypropylene capacitor, 2%	P3393
C13	1	3900 pF polypropylene capacitor, 2%	P3392
C14	1	1000 pF ceramic disc capacitor, 25V, 10%	P4937
C15	1	1 uF mono ceramic capacitor, 50V, 20%	P4968
D1-6	6	1N4001 diode	
J1	1	DB-9, female, solder cup	Note 1
K1-6	6	Hamlin HE3621A0500 reed relay, SPST, 5V @ 10 mA	HE206
P1	1	DB-9, male, solder cup	Note 2
R1,2	2	10K ohm, 1/4 watt resistor, 5%	
R3	1	5620 ohm, 1/4 watt resistor, 1%	
R4	1	51 ohm, 1/4 watt resistor, 5%	
U1	1	MAX038CPP 20 MHz function generator, 20 pin dip	MAX038CPP
Brass Stock	1	0.016 thick brass strip, 3/4 inch wide, 12 inches long	Note 3
	1	0.016 thick brass angle, 1/8 inch sides, 1 inch long	Note 4
	1	0.015 thick brass sheet, 4 x 10 inches	Note 5

Note 1: RadioShack part number 276-1538
Note 2: RadioShack part number 276-1537
Note 3: K & S Engineering part number 233
Note 4: K & S Engineering part number 171
Note 5: K & S Engineering part number 252

Events CALENDAR

MARCH 2000

MARCH 4

CA - REDDING - Hamfest. Shasta Cascade ARS, Jim Bremer KE6OUA, 530-222-8001. E-Mail: ke6oua@arrl.net

KY - CAVE CITY - Hamfest. Mammoth Cave ARC, Larry Brumett KN4IV, 270-651-2363. E-Mail: lbrumett@glasgow-ky.com Web: http://www.scrtc.blue.net/mcarc

NJ - PARSIPPANY - Hamfest. PAL Bldg., Smith Field, Route 46 and Baldwin Rd. VE Testing. Talk-in: 146.52 simplex, PL 131.8, 146.985 out, 146.385 in. Splitrock ARA, Peter Glenn KC2KI, 888-511-SARA or 973-442-7379. E-Mail: KC2KI@qsl.net Web: http://www.ham.hsix.com/sara

OK - ELK CITY - Hamfest. West Central Oklahoma ARC, Earl Bottom N5NEB, 580-821-0633. E-Mail: n5neb@logixnet.net

TN - KNOXVILLE - Hamfest. Kerbela Temple, 315 Mimosa Ave. 8am-4pm. Talk-in: 144.83/145.43 or 146.52 simplex. Shriners of Kerbela ARS, Paul Baird K3PB, 865-986-9562

MARCH 4-5

FL - NEW PORT RICHEY - Hamfest. Technical Education Center, 7825 Campus Dr. 8am-5pm. Talk-in: 146.670. Gulf Coast ARC, Rickie Brown KF4GXS, 727-863-1457. E-Mail: richar@gte.net. Don KK4VK, 727-848-8000. Web: http://www.angelfire.com/fl3/gcarc/index.html

MARCH 5

CANADA - BC - WESTMINSTER - Hamfest. Burnaby ARC, Jim McGill VE7IED, 604-946-9801

NY - LINDENHURST - Hamfest. Knights of Columbus Hall, 400 S. Broadway. 9am-2pm. VE Exams. Talk-in: W2GSB/R 146.685 PL 136.5 (4Z). GSBARC & SCRC, Lenore Dunlop N2KYP, 516-785-0826. E-Mail: info@gsbarc.org Web: http://www.gsbarc.org/hamfest.htm

MARCH 10-11

NE - NORFOLK - State Convention. Northeast Community College, Lifelong Learning Center, 801 E. Benjamin Ave. Fri: 5-9pm, Sat: 8am-5pm. VE Testing. Elkhorn Valley ARC, Fred Wiebelhaus N0VLX, 402-379-1929. E-Mail: dfwiebel@sufia.net Web: http://www.qsl.net/evarc/

MARCH 11

AZ - SCOTTSDALE - Hamfest. Scottsdale ARC, Roger Cahoon KB7ZWI, 480-948-1824. E-Mail: wmgraceco@msn.com

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

CA - LINDA - Hamfest. Yuba-Sutter ARC, Ron Murdock W6KJ, 530-674-8533

CO - CASTLE ROCK - Hamfest. Denver Radio League, Chris Krengel KB0YRZ, 303-789-4736. E-Mail: kb0yrz@yahoo.com

FL - EAST ENGLEWOOD - Hamfest. Tringali Community Center. 8am-1pm. Talk-in: 146.700-. Englewood ARS, George Shreve KA4JKY, 941-697-3445. Ken Anderson W4JQT, 941-475-3172. E-Mail: kba@ewol.com Web: www.flnet.com/~crosby/ears/index.html

FL - SEBRING - Hamfest. Highlands County ARC, Keith Myers KF4YIA, 863-471-2495. E-Mail: kmyers@strato.net Web: http://www.strato.net/~hamradio/

MO - KANSAS CITY - Hamfest. Ararat Shrine, 5100 Ararat Dr. 8am-2pm. Talk-in: 145.13-. Ararat AR Shrine Club, Steve Dowdy WJ0I, 816-941-3392. E-Mail: sdowdy@qni.com Web: http://www.hambash.com

ND - WEST FARGO - Hamfest. Red River Valley Fairgrounds. 8am-3pm. AR license testing. Talk-in: 146.76-. Red River Radio Amateurs, Mark Kerkvliet KG0FR, 701-282-4716. Web: http://www.rrra.org

NH - LONDONDERRY - Hamfest. Lions Club. Talk-in: 146.850. Interstate Repeater Society, Paul Gifford K1LL, 603-883-3308. E-Mail: k1llx@juno.com

WA - PUYALLUP - Hamfest. Mike & Key ARC, Michael Dinkelman N7WA, 253-631-3756 or 425-867-4797. E-Mail: mwdink@eskimo.com

MARCH 11-12

LA - RAYNE - Hamfest. Rayne Civic Center. AARA. Al Oubre K5DPG, 318-367-3901. E-Mail: k5dpg@arrl.net Web: http://www.acadian.net/w5ddl/

NC - CHARLOTTE - Charlotte Hamfest and Computerfair. Charlotte Merchandise Mart, 2500 E. Independence Blvd. Mecklenburg Amateur Radio Society, Tom Hunt KA3VVJ, 704-948-7373 until 9pm EST. E-Mail: hamfest@w4bfb.org Web: www.w4bfb.org

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

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MARCH 12

MA - WESTFIELD - Hamfest. Our Lady of the Blessed Sacrament Parish Center, 127 Holyoke Rd. Talk-in: 146.94 (neg offset, no PL). Mt. Tom ARA, Cindy Loiero K1ISS, 413-568-1175. E-Mail: kissn1fi@javanet.com

PA - YORK - Hamfest. York County Area Vocational-Technical School. VE Testing. Talk-in: 146.97-. Keystone VHF Club, Dick Goodman WA3USG, 717-697-2490. E-Mail: yorkfest@aol.com Web: http://members.aol.com/yorkfest

WI - WAUKESHA - Hamfest. County Expo Center, N.1 W.24848 N. View Rd. 8am-2pm. Talk-in: 146.820 PL 127.3. SEWFARS ARC, John Breecher N9NWN, 414-835-7035

MARCH 18

CT - POMFRET - Hamfest. Eastern CT ARA, Paul Rollinson KE1LI, 860-928-2456. E-Mail: PaulRollinson@worldnet.att.net

FL - STUART - Hamfest. Martin County ARA, Romund Madson KS4KM, 561-337-1841

GA - MARIETTA - Hamfest. JM Miller Park. 8am-3pm. VE Testing. Talk-in: 146.880. Kennehoochee ARC, Charles Golsen N4TZM, 404-252-3303. E-Mail: cgolsen@atlanta.com Web: http://qsl.asti.com/hootch/KARC.html

MI - MARSHALL - Hamfest. Southern MI ARS & Marshall HS Photo Electronics Club, Wes Chaney N8BDM, 616-979-3433

NJ - CLINTON TWP - Hamfest. Cherryville Repeater Assn., Marty Grozinski W2CG, 908-788-2644 or 908-730-2771. E-Mail: w2cg@arrl.net Web: http://www.w2cra@qsl.net

WV - CHARLESTON - Hamfest. Jimmie Hewlett WD8MKS, 304-768-1142

MARCH 18-19

TX - MIDLAND - West Texas ARRL Section Convention. Midland County Exhibit Bldg. Sat: 8am-5pm, Sun: 8am-2pm. VE Exams. Beverly Harwood KC5BNT, 915-686-1841. E-Mail: shamrock@apex2000.net, Web: http://www.lxnet/edge/midswap.htm. Larry Nix N5TQU, E-Mail: oilman@lx.net Web: http://www.w5qgg.org

MARCH 19

IL - STERLING - Hamfest. Challand Middle School Gymnasium, 1700 6th Ave. Talk-in: 146.25/146.85 W9MEP. Sterling-Rock Falls ARS, Lloyd Sherman KB9APW, 815-336-2434. E-Mail: lsherman@essexl.com

MA - UXBRIDGE - Hamfest. Serendipity Hall, 515 Douglas St. 8:30am-3:30pm. Central MA Public Safety Assn., Mike Baril N1PSE, 508-278-3477 ext 1. E-Mail: info@cmpsa.org Web: http://www.cmpsa.org

NY - YONKERS - Hamfest. Yonkers Raceway, Central Ave. and Yonkers Ave. 8am-2pm. FCC Exam. Talk-in: 147.06 114.8 PL. WECA, Thomas Raffaelli WB2NHC, 914-741-6606

OH - MAUMEE - Hamfest. Lucas County Recreation Center, 2901 Key St. 8am-2pm. Talk-in: 147.27+ or 442.85+. Toledo Mobile RA, Paul Hanslik N8XDB, 419-385-5056. Web: www.tmrahamradio.org

WI - JEFFERSON - Hamfest. Tri-County ARC, Katherine Kutz KA9ODI, 920-563-8740. E-Mail: tricountyarc@globaldialog.com

MARCH 24-25

ME - LEWISTON - State Convention. Ramada Conference Center, 490 Pleasant St. Androscoggin ARC, Ivan Lazure N1OXA, 207-784-0350. E-Mail: ilazure@gwi.net Web: http://www.mainearrl.org/convent.htm

OK - TULSA - Convention. Riverside Airport Campus Tech, 801 E. 91st St. Fri: 5-9pm, Sat: 8am-5pm. VE Testing. Talk-in: 145.11 -600 or 443.850 +5. Green Country Hamfest Assn., Merlin Griffin WB5OSM, 918-622-2277. E-Mail: megriffin@ionet.net Web: http://www.greencountryhamfest.org

MARCH 25

IN - COLUMBUS - Hamfest. Bartholomew County 4H Fairgrounds, Community Bldg., SR 11. 8am-2pm. Talk-in: 146.790/146.190. Columbus ARC, Marion Winterberg WD9HTN, 812-342-4670. E-Mail: carc_in@yahoo.com

IN - MICHIGAN CITY - Hamfest. High School, 8466 W. Pahs Rd. 8am-1pm. Michigan City ARC, Inc., Ron Stahoviak N9TPC, 219-325-9089

FL - PLANTATION - Cy Harris Memorial Free Flea. N.E. parking lot of Motorola, 8000 W. Sunrise Blvd. Talk-in: 146.79. Richard Block KG4CHW, kg4chw@arrl.net

OH - COALTON - Hamfest. Jackson County ARC, Edgar Dempsey KD8XL, 740-286-3239. E-Mail: kd8xl@juno.com

TN - TULLAHOMA - Hamfest. Middle TN ARS, Larry Marshall WB4NCW, 931-455-0070. E-Mail: lmarsh@edge.net

WV - BECKLEY - Hamfest. Plateau ARA & Black Diamond RC, James Martin KC8JSZ, 304-465-1428. E-Mail: w373@ientone.net Web: http://members.spree.com/sip1/plateau

MARCH 25-26

MD - TIMONIUM - Greater Baltimore Hamboree & Computerfest/MD State ARRL Convention. Timonium Fairgrounds, York Rd. Sat: 8am-5pm, Sun: 8am-4pm. VE Exams. Baltimore ARC, Sharon Dobson N3QQC, 410-HAM-FEST or 800-HAM-FEST. E-Mail: n3qqc@amsat.org Web: http://www.gbhc.org

MARCH 26

IL - GRAYSLAKE - Hamfest. Lake County Fairgrounds. VE Testing. Talk-in: 146.52 simplex, 147.345 +.600. North Shore Radio Club, Jacob Fishman KF9ZF, 847-291-4160. E-Mail: kf9zf@lightwriters.com Web: http://www.ns9rc.org

MA - FRAMINGHAM - Hamfest. Framingham ARA, Beverly Lees N1LOO, 508-626-2012

OH - MADISON - Hamfest. Lake County ARA, Roxanne N8BC, 440-209-8953. E-Mail: tbrown@ncweb.com Web: http://www.gbhc.org

MARCH 31-APRIL 1

OK - MOORELAND - Hamfest. Tri-State AR Group, Jay Kruckenberg K5GUD, 580-994-2751. E-Mail: redcarpet@pldi.net

APRIL 2000

APRIL 1

CA - HANFORD - Swapmeet. Hanford Fraternal Hall, 10th Ave. @ Florinda. Talk-in: 145.11, 147.33, 224.44, 441.900 PL100. The Kings ARC, Rick 559-945-2266 8am-5pm. Doug 559-582-0949 8am-5pm

CO - LONGMONT - Hamfest. Boulder County Fairgrounds. VE Testing. Talk-in: 147.270+ repeater, 146.52 simplex. Longmont ARC, Fred Pilz KB0UUD, 303-678-5830. E-Mail: larc@qsl.net Web: http://www.qsl.net/larc/

CT - WATERFORD - Ham Radio Auction. Senior Center, Rt. 85. Talk-in: 146.730-. RASON, Tony Griggs AA1JN, 860-859-0162. Web: www.rason.org

MO - LEBANON - Hamfest. Lebanon ARC, Micki Jensen KC0EEX, 417-588-2335. E-Mail: mjensen@llion.org

Continued on page 80

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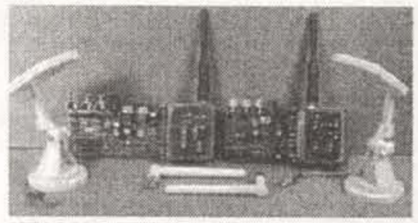

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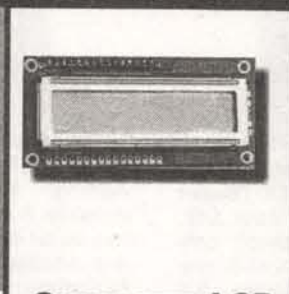

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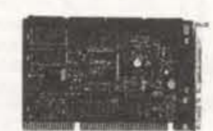

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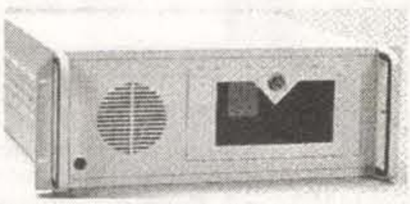

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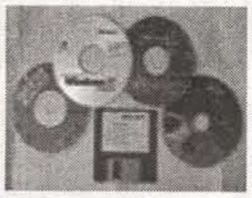

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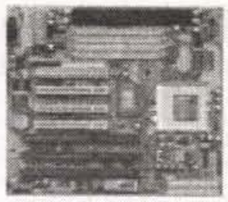

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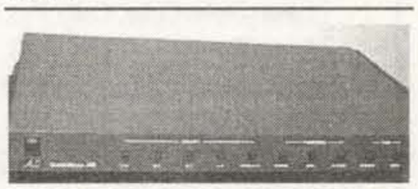

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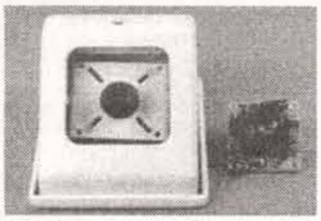

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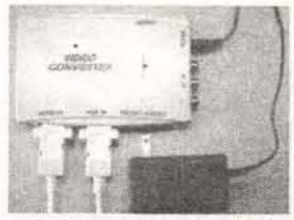

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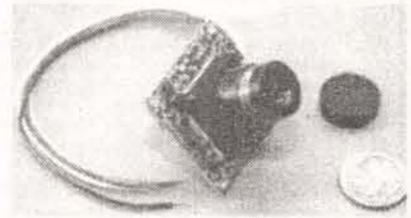

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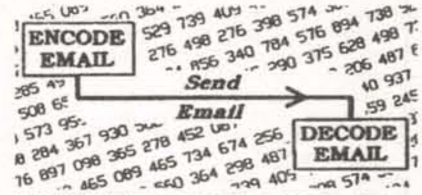

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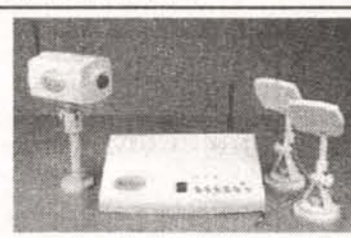

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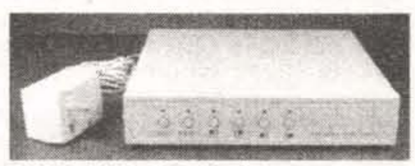

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Continued on page 55

Understanding MP3 Audio Compression

by Robert Kelley

This article will show what an MP3 file looks like, how it works, and a general description of how to decode one.

Overview

The MP3 audio format has become somewhat of a standard method for deploying video and audio media across the Internet. It is used for both live streaming of Internet broadcasts and for storing media files to be downloaded and played back on a PC. However, its most well-known use is in reproducing CD-quality music for distribution over the Internet. There is a fair amount of software available to accomplish this, but not a lot of documentation to explain how it is done. This article will show what an MP3 file looks like, how it works, and a general description of how to decode one.

MP3 is short for the MPEG-x Layer 3 compression algorithm, where x is either '1' or '2.' MPEG stands for Motion Pictures Experts Group. The name refers to a group of developers that work under the joint direction of the International Standards Organization (ISO) and the International Electro-Technical Commission (IEC). Together, these organizations are responsible for the continued evolution of the MPEG algorithms as a whole.

The MPEG format is currently split into two flavors: MPEG-1 and MPEG-2. The first was completed in November 1992, while the latter in November 1994. MPEG-2 adds several new audio features to MPEG-1. These new audio features are a "low sample rate extension," to address very low bit rate applications with limited bandwidth requirements, and a "multi-channel extension," to address surround-sound applications with up to five main audio channels. This extension also provides for an optional extra "low frequency enhancement (LFE)" channel for subwoofer signals. In addition to this, a "multilingual extension" allows the inclusion of up to seven more audio channels.

Each of these two formats is composed of three layers: Layer 1, Layer 2, and Layer 3. These layers differ in that they provide progressively better compression, with increased encoder/decoder complexity and delays.

Backward compatibility between the three layers has been maintained by keeping the same file format. However, due to the differences in encoding, the layers are not upward compatible.

For instance, a Layer 3 decoder

Sound Quality	Bandwidth	Mode	Bit Rate	Reduction Ratio
Telephone sound	2.5 kHz	Mono	8 kbps	96:1
Better than short-wave	4.5 kHz	Mono	16 kbps	48:1
Better than AM radio	7.5 kHz	Mono	32 kbps	24:1
Similar to FM radio	11 kHz	Stereo	56...64 kbps	26...24:1
Near-CD	15 kHz	Stereo	96 kbps	16:1
CD	>15 kHz	Stereo	112...128 kbps	14...12:1

FIGURE 1: MPEG LAYER 3 TYPICAL PERFORMANCE DATA

MP3 is short for the MPEG-x Layer 3 compression algorithm, where x is either '1' or '2.' MPEG stands for Motion Pictures Experts Group.

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With USB, the I-Jam player is both Windows and Macintosh compatible, making it a complete cross-platform device. In addition, with USB, an open specification that makes the task of connecting peripherals to a computer easier and less time-consuming. Using the new player can be a true plug-and-play experience.

Using the I-Jam player is simple. In a manner similar to recording off a cassette tape, the I-Jam player takes advantage of a storage drive called the Jam Station™. With it, MP3 files are transferred onto the MultiMediaCard within minutes.

The MultiMediaCards are compatible with the Secure Digital Music Initiative (SDMI). Formed by major record labels under the auspices of the Recording Industry Association of America, SDMI is developing a new technology standard for secure downloading of audio and other information from the Internet.

The I-Jam player measures three inches high by less than two inches wide and is available in blue, red, silver, yellow, and black. The suggested retail price is $299.00. It is currently on sale at major retailers including Target, Comp USA, Sharper Image, D & H Distributors, FingerHut, Sound Advantage, J & R MusicWorld, and ValueVision. It is also available through Amazon.com, Outpost.com, and I-Jam's virtual store at www.ijamworld.com.

I-Jam Multimedia LLC, headquartered in Schaumburg, IL, was formed in 1999 to develop and market micro-sized, multimedia products in the digital audio and video categories. Contact I-Jam at 1-888-326-4526, 847-839-0016 Fax, or 1208 Remington Rd., Schaumburg, IL 60173. Visit their website at www.ijamworld.com.

30 MINUTES OF MUSIC WITH IJ-90V

A voice recorder that plays MP3 files, the IJ-90V, also from I-Jam, is a powerful device that can accommodate over 30 minutes of CD-quality music, or about two hours of voice data. The IJ-90V uses Smart Media Memory cards, comes bundled with one 32MB card, and has a built-in loudspeaker for playback of voice recording files and radio listening. Earphones are supplied with each unit. The IJ-90V can connect directly to a PC using the supplied parallel port connector to download MP3 music files or upload voice recordings for archive purposes.

The IJ-90V uses external memory and comes in either blue, red, yellow, black, silver, or purple. Memory card readers are available for both the PC and Macintosh, including JS-100C Compact Flash Memory cards with parallel port, JS-101C with USB ports, and PCA-100C for portable computers with PCMCIA slots. It has a suggested retail price of $179.00.

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can decode any Layer 1 or Layer 2 encoded sample, but a Layer 2 decoder cannot decode a Layer 3 encoded sample. This article deals with the third layer, which is the most widely used and is what is employed in the "MP3" format.

In terms of compression, MPEG-2 Layer 3 encoding can achieve CD-quality compression at 12:1. Figure 1 shows the various compression rates that can be achieved, and the associated signal quality that comes with them.

How Does It Work

MPEG, in any layer, is a perceptual coding scheme. This means that it exploits the inherent properties of the human ear while trying to maintain the original sound quality of the sample. These properties appear as limitations in that the ear has trouble identifying more than one frequency if a tone becomes dominant for a specific period of time.

The frequencies in the vicinity of this tone are less audible, if the energy falls below a certain threshold called a masking threshold. In the most simple of terms, the algorithm removes the inaudible portions of the sample leaving only what the human ear can hear. The compression results in very little signal degradation, but the original sample can never be recovered. Instead, the signal will be perceptually identical to the human ear.

The MP3 Format

The content of the MP3 file is organized into a number of frames. The frame consists of information to construct 1,152 samples of data. The samples are sub-divided into two granules, each 576 samples in size. Each granule contains Scale Factors and Huffman Encoded Bits, which is where the actual audio data is located, and will be discussed in further detail later. The composition of the frame takes on five distinct parts: a Header, CRC, Side Information, Main data, and Ancillary data. Figure 2 illustrates this.

Header

The Header portion of the MP3 frame is a fixed 32 bits in size and contains a synchronization word and system information. The first 12 bits of the header are known as the synchronization word. This word marks the beginning of the frame and must be set to the binary equivalent of all ones. See Figure 3 for a graphical breakdown of the header. The following is a detailed breakdown of each element of the header, and what it means:

ID: The ID of the audio algorithm used. A '1' indicates that ISO/IEC 11172-3 audio was used.

Layer: Indicates which layer was used. Possible values are 1, 2, or 3. Zero is not defined.

Protection Bit: A value of '1' indicates that there are two CRC bytes appended to the end of the header.

Bit Rate Index: Indicates the bit rate used. Allowable bit rates vary depending upon which layer is used. The index corresponds to an index into an array of possible bit rate values.

Sampling Frequency: Indicates the sample frequency of the audio sample. This value is also an index into an array of possible values.

Padding Bit: Indicates whether or not an additional byte has been added to the frame in order to adjust the mean bit rate to the sample frequency.

Private Bit: A bit designated for private use.

Mode: One of four possible mode values: Stereo, Joint-Stereo, Dual Channel, or Single Channel.

Mode Extension: Indicates which type of joint stereo method was used: Intensity Stereo or MS Stereo.

Copyright: Indicates if a copyright exists.

Original/Copy: A '1' indicates that the sample is an original, a '0' indicates that it is a copy.

Emphasis: Indicates what type of pre-emphasis must be used.

CRC

The CRC is two bytes in length and is optionally found after the header. It provides a limited amount of error checking primarily for the decoder. Because only the most critical portion of the frame is included in the CRC, it's composed of only bits 16 through 31 in both the header portion, and the side information portion.

An error occurring in any other part of the frame will corrupt the data itself, and may or may not be distinguishable during playback. However, an error in these critical bits will corrupt the frame and the results will be much more noticeable.

Standard error handling procedure is to mute the bad frame or retransmit it. Ultimately, it is up to the specific implementation of the decoder.

Side Information

The primary purpose of the side information section of the frame is to hold the necessary information to decode the main data. Without it, the main data cannot be decoded properly, hence the need for the optional CRC implementation to verify this information.

Specifically, this section contains Huffman tables, which are used during the Huffman decoding process (explained later) and information for the reconstruction of the scale factors. Both of these elements of data are located in the Main Data portion of the frame.

The side information also indicates where the main data begins in the current frame via a nine-bit main data pointer. This is necessary because of the use of a mechanism known as a "bit reservoir." The bit reservoir is used to hold extra data in the next frame should the main data require more space than is available in the current frame.

This section is 17 bytes in length for single channel mode, and 32 bytes for dual channel mode. See Figure 4 for a breakdown of Side Information. The following is a detailed breakdown of each element of Side Information, and what it means:

Main Data Begin: A nine-bit pointer to the location of the start of the Main Data that belongs to the given frame. This pointer value is a negative offset from the first byte of the synchronization word.

Private Bits: These bits are user-defined and can be used by the encoder.

SCFSI: (Scale Factor Selection Information) Determines whether one scale factor is sent for each granule, or for both granules, per channel. Four bits are required for this per channel, and each bit corresponds to a group of scale factor bands. A value of zero means that scale factors are transmitted for each granule for that particular group of scale factor bands. A one means that the same scale factors are used, therefore only the scale factors for the first granule are transmitted.

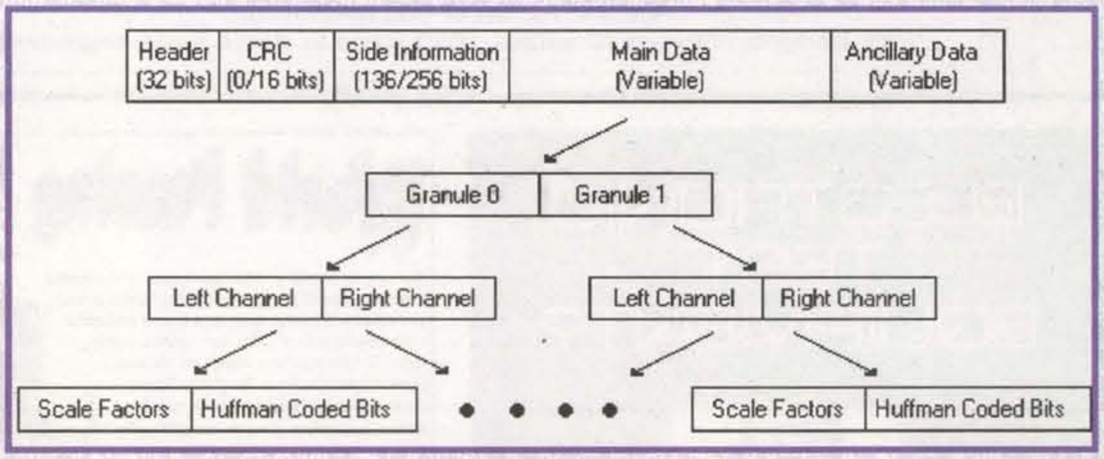


Figure 2: MPEG Layer 3 Frame Organization. This diagram represents a dual-channel frame (stereo). Note: The Side Information section of the frame has a similar organization except that it contains information common to each channel in each granule.

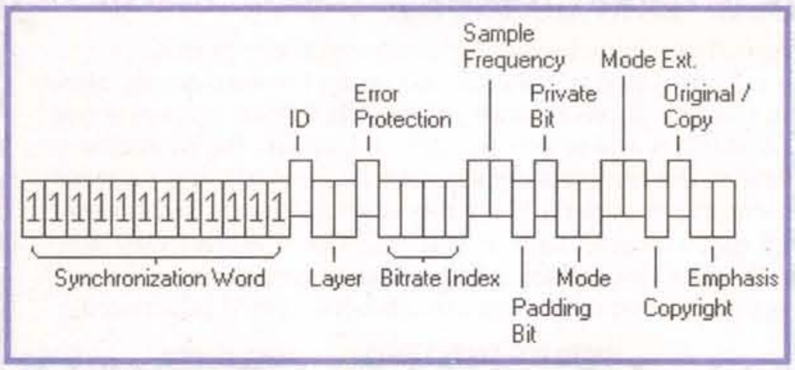


Figure 3: MPEG Layer 3 Header Format. Note: Each box represents one bit.

Side Information for each granule

The side information specific to each granule is broken out in Figure 5. The following is an explanation of each of the elements:

Par23Length: The number of main data bits allocated for Scale Factors and Huffman Encoded Data. This variable can be used to determine the beginning of the next granule since the width of Side Information is constant.

Big Values: Indicates the size of the big value portion of each granule. The Big Value portion of the granule is defined as one of three partitions of values after the quantization of the 576 samples of the granule. The partitions include rzero, count1, and big values.

Global Gain: Contains information about the step size used in the quantizer where the quantization is done logarithmically.

Scale Factor Compress: Variable transmitted for each granule. Indicates the number of bits used for the transmission of scale factors. It is an index into a table of values that returns two numbers which correspond to the number of bits in the first and second group of scale factor bands.

Windows Switching Flag: A flag that indicates whether or not a normal window is being used. A value of zero defines the normal window; a non-zero value indicates some other type of window. This flag influences what the next 22/44 bits of data will look like.

Block Type: Indicates what type of window is used in a particular granule.

Mixed Block Flag: A flag that indicates that different types of windows is used in the lower and higher frequencies. If set, it means that the two lowest sub-bands are transformed using a normal window (as if Block Type was set to zero), and the rest of the bands are transformed using whatever window is specified in Block Type.

Table Select: Allows for the use of different Huffman code tables. There are 32 possible tables that can be used.

Sub-block Gain: Enables a gain by a factor of four for one sub-block. This feature only works when short windows are chosen (Block Type = 2).

Region 0 Count: In order to improve the performance of the Huffman encoder, the Big Values portion of the Granule Side Information is divided into three regions. This is the size of region 0.

Main Data Begin	Private Bits	SCFSI	Side Info Gr. 0	Side Info Gr. 1
9 bits	5 or 3 bits	4 or 8 bits	59 or 118 bits	59 or 118 bits

Figure 4: Format of Side Information.
Note: Elements with two bit values reflect mono or stereo mode, respectively.

Region 1 Count: The size (number of bits), of region 1 of the Big Values data.

Pre-flag: Indicates that additional amplification was used in the higher frequencies of the quantized values. The value of this variable is added to the scale factors and is not available when short windows are chosen (Block Type = 2).

Scale Factor Scale: Determines how the scale factors are quantized logarithmically. The possible methods are with a step size of two, or the square root of two.

Count 1 Table Select: A flag that indicates which of two possible Huffman code tables was used to code the partition count1.

Main Data

Main Data consists of three types of data: Scale Factors, Huffman coded bits, and Ancillary Data.*

Scale Factors: The Scale Factors are used to color the quantization noise. They are transmitted for every group of frequency lines, or Scale Factor Bands. Scale factors can be sent for each scale factor band per granule or not. This is determined by the before-mentioned SCFSI variable. The exact number sent also depends upon what type of Window has been specified.

Huffman Coded Bits: The Huffman Coded bits are one of the major reasons why the MP3 format can achieve such high compression rates while still maintaining superior sample quality. They work via the encoding of the likeness of data within the stream. A table is first created showing the distribution of like and unlike data across the stream. This table is then parsed and codes are assigned to each entry. Data that has a high probability of being found more often are assigned a short code, while data that is rarely present are assigned a much longer code. Thus, decoding the data results in a new representation of it, but with fewer bits.

Ancillary Data

Ancillary data is optional data added to the end of the file. It is most commonly used to provide information about the media encoded, such as the name of a song. The size of this data is variable, and is determined by subtracting the sum of the header, CRC, and audio data from the total size of the frame. It lies from the end of the Huffman encoded bits to the loca-

tion pointed to by the next Main Data pointer.

Par23Length	**Big Values**	**Global Gain**	**Scale Factor Compress**	**Windows Switching Flag**
12 or 24 bits	9 or 18 bits	8 or 16 bits	4 or 8 bits	1 or 2 bits
Block Type	**Mixed Block Flag**	**Table Select**	**Sub-block Gain**	
2 or 4 bits	1 or 2 bits	10 or 20 bits	9 or 18 bits	
Table Select	**Region 0 Count**	**Region 1 Count**		
15 or 30 bits	4 or 8 bits	3 or 6 bits		
Pre-flag	**Scale Factor Scale**	**Count 1 Table Select**		
1 or 2 bits	1 or 2 bits	1 or 2 bits		

Figure 5: Format of Side Information for each granule (1 and 2) section of the Side Information block. Note: The data bits in the first row are always transmitted. The data bits in only one of the second or third rows are transmitted, depending upon the value of Windows Switching Flag. The fourth row of data bits is always appended to either the second or third.

Decoding the Data

Once a frame has been received, the first thing done must be to parse the header. First, the synchronization bits must be verified. If they are all set, then the synchronization is valid and the CRC can be checked, if it is present. If the CRC checks out, then it is time to collect data from the Side Information section of the frame to learn the characteristics of the Huffman Encoded bits. This includes where to find the Huffman Encoded bits in the stream, which tables to use to decode them, and whether ESCAPE codes are present. In addition, the decoder must ensure that all 576 frequency lines have been generated even though not all of them may have been used. In that case, the unused lines must be padded with zeroes.

Now that it is known how the Huffman Encoded bits were encoded, they can be decoded. The end result of running the algorithm is to obtain the scaled, quantized frequency lines. These lines are then used with the results of the Scale Factor Decoding algorithm to begin the De-scaling process.

The Scale Factor Decoding algorithm decodes the scale factors, which are the first part of the Main Data section of the frame. Both the Scale Factor info and the coded scale factors are used as input to this algorithm, and are found in the Side Information section of the frame.

It is during the next phase of decoding known as De-scaling, where the real benefits of MP3 compression are realized. As mentioned earlier, the scaled and quantized frequency lines generated by the Huffman Decoder are used together with the reconstructed scale factors from the Scale Factor Decoding algorithm to generate a perceptual copy of the original frequency lines.

The next step in decoding the data is to perform Reordering. Reordering is necessary because the frequency lines generated by the De-scaling algorithm are not always ordered in the same way. This occurs when the encoder uses different window methods. A long window would generate frequency lines ordered first by sub-band, then by frequency. With short windows, the reverse is true. Therefore, this must detect what type of window method was used, and reorder the values, if necessary.

At this point, all of the frequency lines are properly ordered, and primarily decoded. Now it is time to perform the necessary processing to convert the encoded stereo signal, if it is a stereo sample, into separate left/right stereo signals. From this point on, the rest of the algorithms applied to the data will do so for each of the two separated stereo signals. The following algorithms are a bit more complicated, and will be touched on briefly.

The first of these algorithms is called Alias Reduction. In this phase, the aliasing artifacts are added to the signal gain. This process consists of eight butterfly calculations for each sub-band.

Next, an Inverse Modified Discrete Cosine Transformation (IMDCT) is performed. The frequency lines from the alias reduction are mapped to polyphase filter sub-band samples. This calculation differs between different values of Block Type. Possible frequency inversions in the polyphase filter bank, created from the previous algorithm, are handled next by multiplying every odd time sample of every odd subband by –1. This is known as the Frequency Inversion step.

The last step is to synthesize the polyphase filter bank. Each time a sample, from each of the 32 subbands has been calculated, it is applied to the synthesis polyphase filter bank and 32 consecutive audio samples are calculated.

After running this algorithm on the frequency lines, the end result of the decode is achieved with the data in raw, PCM (Pulse Code Modulated) format. The data is packed in one or two bytes per sample, depending upon which mode is being employed, mono or stereo, respectively. This raw data can be streamed directly to a sound card and played back. Windows Wave (.WAV) files often use this format, which is why files of this type tend to be so large. Figure 6 shows the entire decode process from beginning to end.

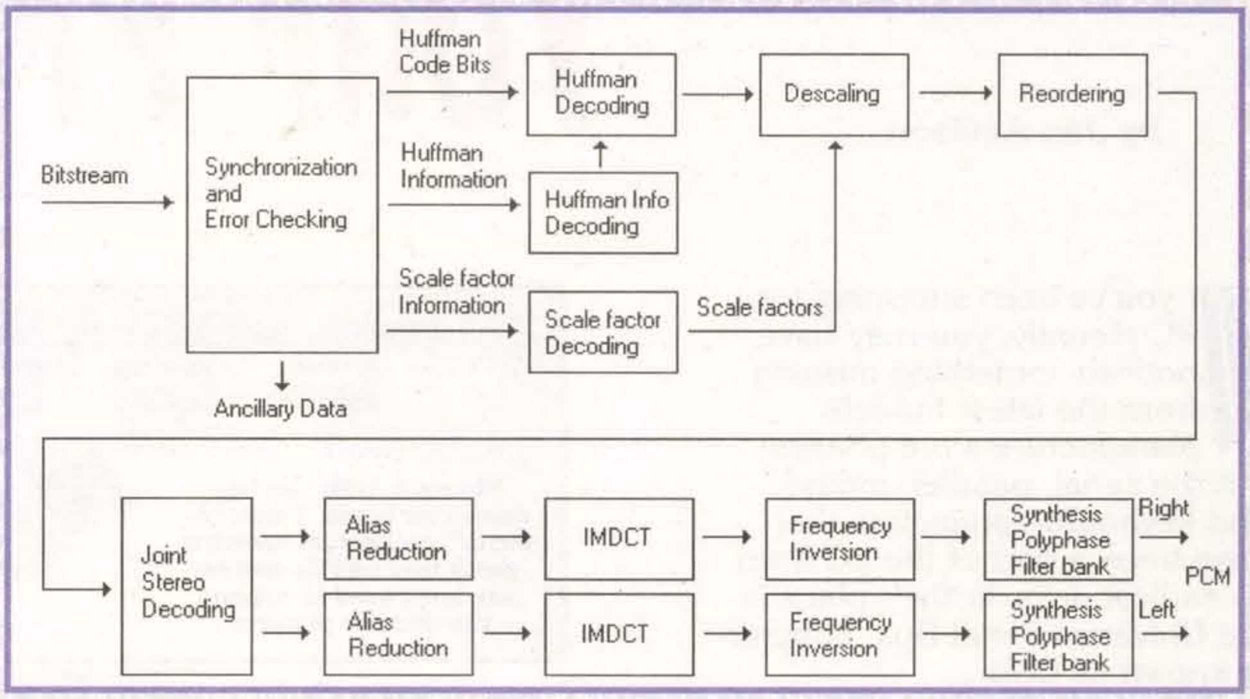


Figure 6: Decoder flow diagram. Shows the steps that an MP3 decoder must take to convert a compressed sample back into PCM (Pulse Code Modulated) signal format.

Summary

This article only scratches the surface on providing the amount of information necessary in order to create an MP3 decoder. Unfortunately for media player developers, information about the MP3 file format is difficult to come by.

Only a handful of sources contributed to the information contained within this article as it is expensive to purchase the specifications directly from IEEE. Source code is available on the Internet, which is written in 'C' and/or Assembly, that applies this information to the development of an MP3 encoder/decoder.

The following FTP site contains some public domain source code written in the C programming language. This code was written for demonstration purposes, but it should prove a sufficient springboard for creating an MP3 Encoder/Decoder. The site is: ftp.iis.fhg.de/pub/layer3/public_c/. **NV**

Contributing work

1. The Masters Thesis of Kent Salomonsen, Sten Sogaard, and Eddie Proft Larsen for the Institute of Electronic Systems, Department of Communication Technology, at Aalborg University, Denmark.

2. Fraunhofer IIS web site: www.iis.fhg.de

Put USB in Your Projects

Take advantage of the new Universal Serial Bus port in the projects you design and build.

by Jan Axelson

If you've been shopping for a PC recently, you may have noticed something missing from the latest models. Manufacturers are phasing out the serial, parallel, mouse, and keyboard connectors that have been a part of the PC from its earliest days. In their place is the Universal Serial Bus, popularly known as USB.

The reason for the switch is that USB promises a faster, easier to use, and more flexible interface than the mishmash of older, "legacy" ports. This is good.

But what does USB mean for experimenters and other designers of custom hardware that connects to the PC? Can you use a USB port to connect to sensors, control circuits, robots, displays, switches, and other custom designs that formerly used the parallel and serial ports?

In short, the answer is yes. But USB is very different from the older interfaces and so requires a different approach. This article will introduce you to USB and describe the options for designing devices that connect to USB ports.

Figure 1. USB has two connector types. These "A-series" connectors are what you'll find on PCs and on any hubs used to expand the number of ports.

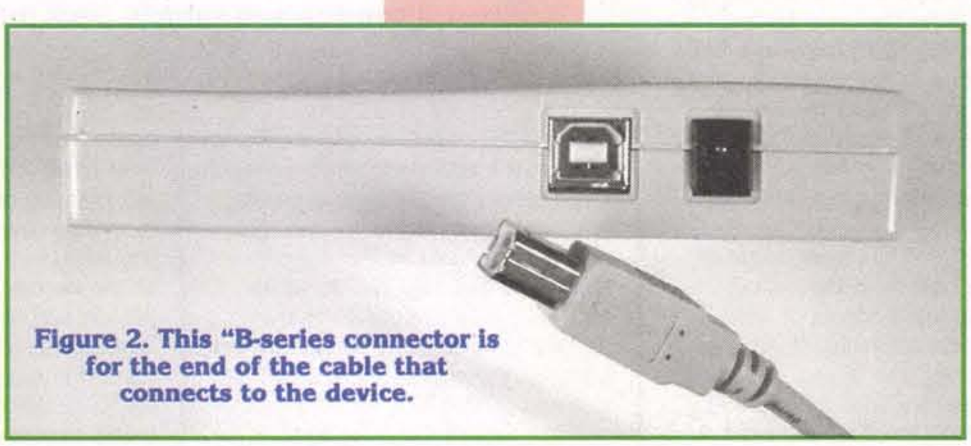


Figure 2. This "B-series connector is for the end of the cable that connects to the device.

USB Essentials

So what is USB anyway? It's intended to offer a way to attach just about anything you might want to hook up to a PC. You can use a USB port in standard peripherals like a mouse, joystick, keyboard, and external drives, as well as in specialized equipment, including your own designs. Figures 1 and 2 show USB's cable and connectors.

The creators of USB have gone to great effort to make the interface easy for folks who just want to be able to buy a peripheral, plug it in, and start using it without puzzling over cables, connections, settings, drivers, etc. (Not an unreasonable request!) USB peripherals have no user configuration settings. They don't require IRQ assignments (which are always in short supply on PCs). You don't have to power down or reboot when you install a new peripheral. Most PCs come with two USB ports, and you can add more with inexpensive hubs that convert a single port to many.

And here at last is an interface that includes its own power-supply line. A peripheral can draw up to 500 milliamperes from the bus. This means that many projects will no longer need a battery or "wall-wart" supply.

But USB isn't *all* good news. A side effect of making USB easy for its end users is greater complexity for anyone who wants to design and program a USB device. But I'll show ways to save time and trouble by making the right choices in hardware and programming options.

What's Inside a USB Device?

Before you can start designing a device with a USB port, you need to know something about what's inside a USB peripheral. Every USB device must contain an intelligent controller that knows how to respond to requests defined by the USB specification.

If you're familiar with the UARTs that control RS-232 ports, USB controllers perform a similar function. Both are responsible for translating between two formats: The format used by the data as it travels in the cable and a format that's understandable to the CPU that wants to send and receive data on the cable.

USB peripherals have no user configurations settings and don't require IRQ assignments. You also don't have to power down or reboot when you install a new peripheral.

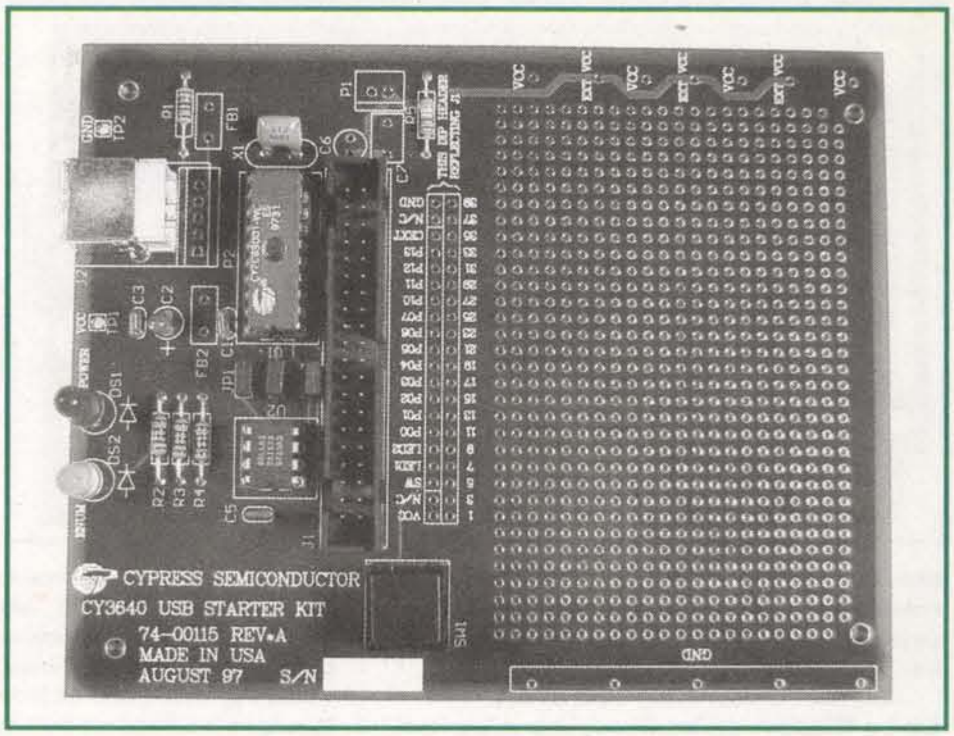


Figure 3. The Cypress Starter Kit includes circuits for a thermometer project.

But because USB is much more capable than RS-232, a USB controller is more complicated than a UART.

There are dozens of USB controllers available, most from familiar chip vendors like National Semiconductor and Cypress. Some controllers are general-purpose microcontrollers with USB functions built in. Others handle only the USB-specific duties, and have a serial or parallel interface that must connect to an external microcontroller.

In all cases, much of the burden of USB communications is handled by the hardware. For example, on receiving data, the device often must return a status code that indicates either that the data was accepted or that it was refused because the chip was busy or detected an error. The returning of the status code is normally handled automatically by the hardware.

Sources

USB Central
www.lvr.com/usb.htm
This is my page with links to all kinds of information for USB developers, including the specification documents, chip vendors, other useful products, and example code.

USB Implementers Forum
http://www.usb.org
The specification documents, free development tools, and discussion boards.

USBSimm Support Site
http://usbsimm.home.att.net/

ActiveWire-USB
http://www.activewireinc.com

Cypress/Anchor Chips EZ-USB
http://www.anchorchips.com/ez_usb.htm

Cypress CY7C63000
http://www.cypress.com/usb/index.html

An example of a general-purpose microcontroller designed from the ground up for USB applications is Cypress Semiconductor's CY7C63000. It's the chip inside Microsoft's Intellimouse, and it's also suitable for other devices that just need to transfer a few bytes to or from a PC at intervals. The chip has 12 I/O pins that you can use for any purpose and two kilobytes of EPROM for program storage. (Chips with more I/O and program memory are also available.) The chip is available in a DIP package for easy prototyping.

Other controllers consist of an existing microcontroller with a USB interface added. If you have experience with a particular chip and a USB variant is available, that would be a natural choice to use in your projects. Fans of Microchip's PIC family can look forward to the PIC16C7x5 chips.

Cypress' EZ-USB uses a variant of the popular 8051 family. The EZ-USB has the ability to load its program code automatically from a PC every time it's attached, so you don't need an EPROM programmer or special development system to store code inside the chip. Compared to the CY7C63000, the EZ-USB is more capable in just about every way. Its USB port is faster and can do more, and the chip has more memory, a bigger instruction set, and more timers and other ports (and more pins). Although the overall architecture of the chip is more complex, the hardware handles more of the USB communications automatically.

How to Develop a USB Device

As with all microcontroller projects, designing a USB device requires skills in both hardware design and programming. It also requires some specialized tools, though there are ways to keep the cost to a minimum.

To write the code that resides inside your device, some experience in programming microcontrollers is helpful. Most of the chip vendors provide sample code that's a big help in getting started.

You'll also need a basic understanding of how USB works, including the different transfer types and speeds available. The ultimate source of information is the specification that defines the interface. It's available free online. But before tackling this, I recommend beginning with a more concise and basic explana-

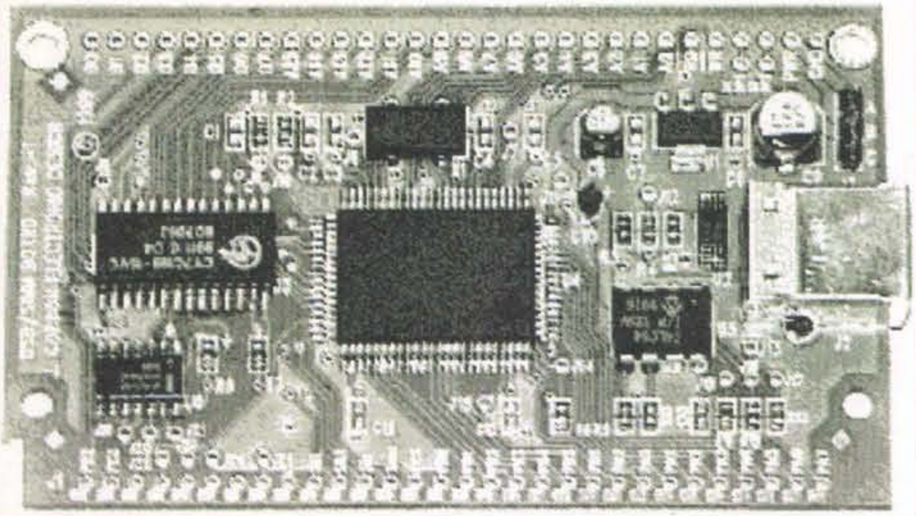


Figure 4. The USBSimm is an inexpensive way to get started with the EZ-USB chip.

tion. Cypress' Starter Kit has an application note with a good description of USB from the developer's viewpoint. The note is available online.

On the PC side, every USB device must have a Windows device driver. This is low-level software that manages the communications between the drivers that control the USB hardware in the PC and the applications that want to access the device. Writing a device driver is not a trivial task! Fortunately, many projects can use drivers built into Windows 98 or provided by chip vendors.

To use USB on a PC, Windows 98 (or Windows 2000) is recommended. Both have built-in support for USB. Although it's possible to use some UBS peripherals with later editions of Windows 95, the support under '98 is much expanded and improved. NT4, DOS, and Windows 3.x have no built-in support for USB.

(This article concentrates on Windows PCs. Apple's iMac is ahead of the game with an all-USB computer. And support under Linux and other operating systems is in progress.)

Windows 98 comes with drivers for HID-class devices, which can include just about anything that communicates at speeds of 64 kilobytes per second or less. HID stands for human interface device. The classic HIDs are the keyboard and mouse, where a human's actions cause the device to send data to the PC. But a HID doesn't have to have a human interface at all. An analog-to-digital converter can be a HID, and so can a motor control circuit.

To use the HID drivers, your device must contain descriptors, which are blocks of data with a defined format. The descriptors identify the device as a HID and describe the format of the data that the device will send and receive. Windows requests this information when it first detects that the device is attached. After Windows has learned about the device, it's ready to exchange other data. The device typically places data it wants to send in a transmit buffer, and retrieves received data from a receive buffer. The controller chip handles most of the details of exchanging data with the PC.

Another option is to use a driver provided by the chip vendor or another source. The EZ-USB comes with a driver that you can use to send and receive data using all of the transfer types defined by the specification.

When you have a driver installed, applications can access your device by calling Windows API (application programmer's interface) functions. You can do this in just about any programming language, including Visual Basic, Delphi, and C/C++. Calling API functions can be tricky. Windows may respond

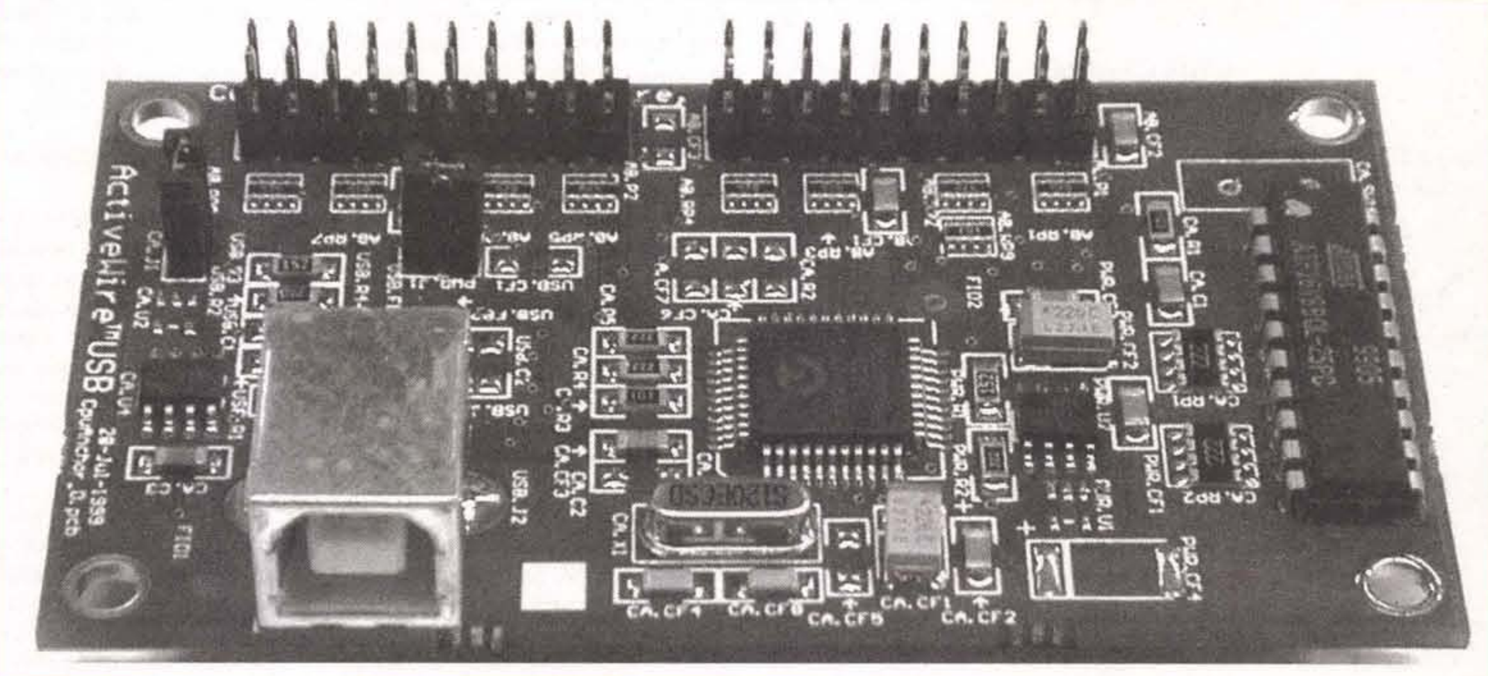


Figure 5. The ActiveWire-USB also contains an EZ-USB and port bits available for any use.

As with all microcontroller projects, designing a USB device requires skills in both hardware design and programming.

harshly if the data you pass doesn't meet its exacting expectations! So some experience here is helpful, as well. But again, in most cases, example code is available to help.

Tools

As with any microcontroller project, you'll need development tools for assembling or compiling your device's program code, for loading the code into your device's memory, and for testing and ferreting out the inevitable bugs.

The vendors of USB microcontrollers offer free assemblers, and C compilers are also available for many chips. For loading your code into your CPU, the vendors also provide tools, and some third-party tools are available. I'll describe a few of the most popular and inexpensive ones.

For the CY7C63000, Cypress provides two options. The $99.00 Starter Kit contains a PC board with a chip, thermometer circuits, and proto area for custom designs (Figure 3), an assembler, sample chips, and an EPROM programmer for burning your assembled code into the chip. The main drawback to the Starter Kit is that every code change requires burning a new EPROM, so you'll need to have your EPROM eraser ready for frequent action. The Starter Kit is worth getting for the EPROM programmer, however.

The $499.00 Developer's Kit contains a PC board and monitor program that enable you to load your assembled code from a PC into the board's RAM for testing. With the monitor program, you can also view the contents of the chip's registers and memory, and control program execution. The ability to run the code from RAM is much more convenient than the EPROM-only route.

For the EZ-USB, there are two inexpensive development boards that you can use in two ways. For basic reading and writing to port pins, you can use the provided drivers and device code. You can write applications that read and write to the port pins, without having to do any device programming or driver writing. Or, for fully custom designs, you can use your own device code and/or drivers with the boards.

The boards are the $79.00 USBSimm from J. Gordon Electronic Design (Figure 4) and the $59.00 ActiveWire-USB from ActiveWire (Figure 5). (See ActiveWire's ad in the NV ADMART section of this issue.) Either will give you a quick way to get started with USB projects.

Both are credit-card size PC boards containing an EZ-USB chip, a USB connector, and connections to port pins. Both provide device drivers, device code, and application examples. The USBSimm has 20 port bits available for any use, an external data bus, and 32 kilobytes of extra RAM. The ActiveWire-USB has 16 port bits available for any use and, in addition to Windows drivers, has drivers for Linux, LabView, and more.

Cypress also has a $495.00 development system for the EZ-USB.

While you're developing a project, it's also helpful to have a way of viewing the data on the bus. To help with this, the USB Implementers Forum provides the free USBCheck suite of tools for testing.

Another option is a protocol analyzer, which is a hardware/software combination that enables you to view all of the data on the bus in a variety of formats. (An oscilloscope doesn't help much with USB, because the data on the bus is encoded.) Protocol analyzers are extremely useful, but pricey, beginning at around $4,000.00. It's possible to develop simple projects without a protocol analyzer, however, and I think in time the prices will drop.

Wrapping Up

That completes our whirlwind tour of USB for developers. If you'd like to see more USB articles in *Nuts & Volts*, let me know at jan@lvr.com. I'm also interested in knowing if there's a particular USB-related topic you're interested in. **NV**

Jan Axelson (jan@lvr.com) is the author of *USB Complete: Everything You Need to Design Custom USB Peripherals.*

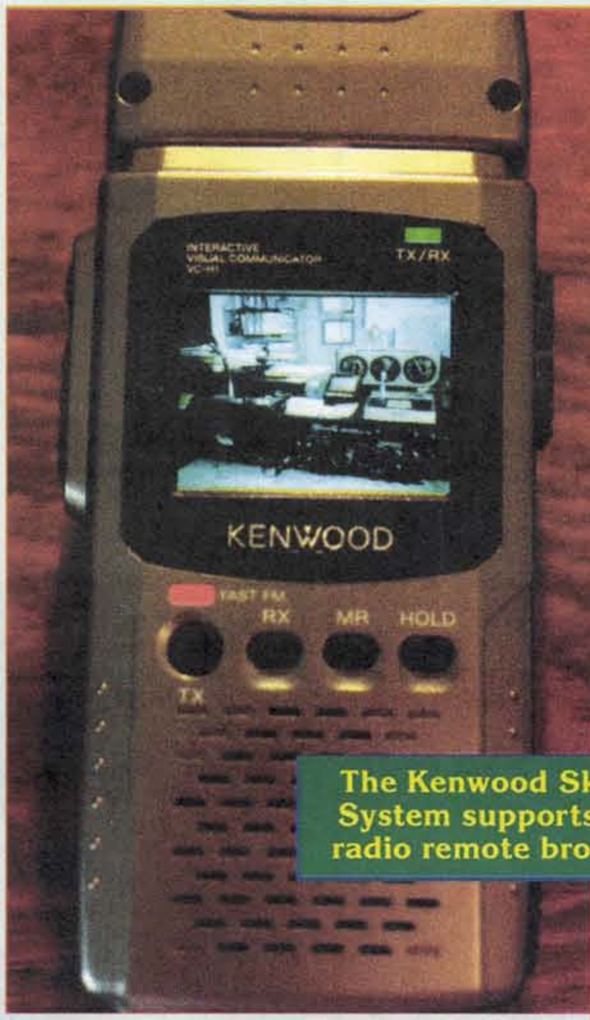
by
Gordon West

WORKING WORLDWIDE HF ON A TINY DUAL-BAND HAM RADIO

One thing for sure — those little tiny handheld radios that hams talk through "repeaters" with won't normally talk for more than a couple hundred miles because they operate on extremely short wavelengths that don't skip off the ionosphere.

Until now.

You can now put together a ham radio system that lets you work your worldwide station remotely with a little ham radio dual-band handheld.



With the new Federal Communications Commission (FCC) proposed rules dropping the Morse Code speed to 5 wpm for worldwide General class operation, Technician class hams by the thousands are upgrading for worldwide privileges with the General class license. Some Tech-plus operators may be grandfathered to the new worldwide General license without having to do a thing!

The amateur radio General class license allows you to operate voice on a portion of all ham radio worldwide bands. These ham bands provide frequencies that easily reflect and refract off of the ionosphere, allowing for two ham operators to chat back and forth thousands of miles away. During daylight hours, best ham communications are on the 10-meter, 12-meter, 15-meter, and 20-meter bands. When darkness sets in, ham operators may switch to 40 meters, 75 meters, and 160 meters to take advantage of the waning ionosphere.

While it doesn't take much more power than a 25-watt lightbulb to bounce signals off the ionosphere, it does take a good high-frequency antenna system to properly launch and receive these distant signals. The ham operators using the worldwide bands from their vehicles usually have a big fat six-foot or higher whip that might have multiple coils on it, or a big fat coil in the center.

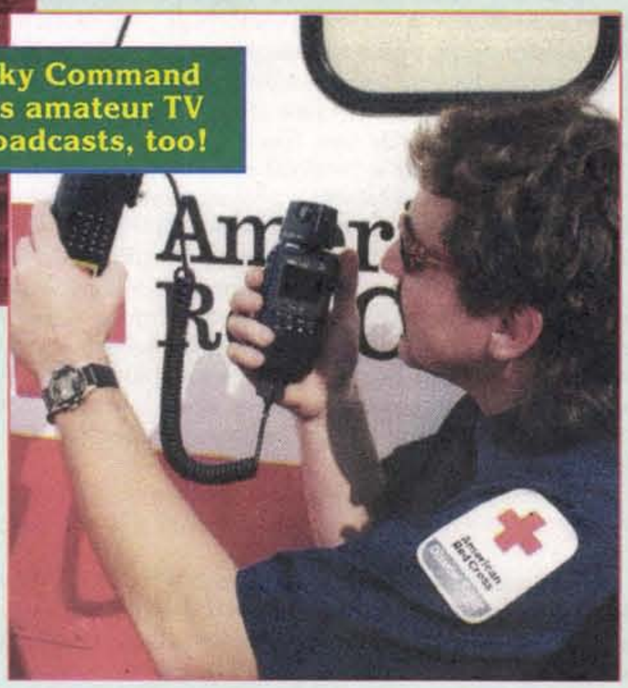
Ham operators who bounce signals off the General class worldwide airwaves may use large three-element beam antennas on their home's roof. And in areas of antenna restrictions, some hams will hide dipole wire antennas within the attic. But one thing for sure about worldwide operation – you need a good antenna system and you need to keep the antenna away from noise sources like florescent lights, computers, and cable TV drops. And ham operators are also sensitive that transmitting on any antenna near computers, cable TV lines, and home audio systems could result in unwanted interference from their signals.

And one other thing for sure – those little tiny handheld radios that hams talk through "repeaters" with won't normally talk for more than a couple hundred miles because they operate on extremely short wavelengths that don't skip off the ionosphere.

Until now.

You can now put together a ham radio system that lets you work your worldwide station remotely with a little ham radio dual-band handheld. Imagine the excitement of a school teacher going into the classroom, pulling out their little ham radio handheld, calling CQ, and ending up with a station coming in 8,000 miles away! Or the emergency communicator who may set up a Red Cross radio system at an evacuation center, and with a little handheld, be able to communicate to other emergency operators throughout the United States via skywaves. And, if you work in a high rise in a big city, you can still end up with worldwide ham transmissions coming over your little handheld radio, too.

The whole idea behind this system was put together by well-known ham manufacturer Kenwood Corporation.



The Kenwood Sky Command System supports amateur TV radio remote broadcasts, too!

"Remote worldwide high-frequency operation is not new to some hams, and it has been experimented with for years," comments Paul Middleton KD6NOH, with Kenwood Corporation. "This worldwide capability is achieved by using a small VHF/UHF dual-band handheld or mobile sys-

Where's the signal coming from? Radio operators check out the Kenwood radio remote control system in the comm van

tem in conjunction with one of our high-frequency transceivers. It works great when you can't take your big power supply and your big worldwide radio and your big directional antenna with you when you go into work," adds Middleton.

Kenwood calls it the Sky Command System, and it is a plug-and-play set-up with no soldering iron needed or any experience in writing computer codes. But the system does revolve around the exclusive use of specific Kenwood transceivers with built-in Sky Command capabilities.

The worldwide radio is the Kenwood low-priced TS-570 D/S or medium-priced TS-870 S. These are worldwide radios that are hooked into your mobile multi-band antenna system, or at a remote location with a big tower and big directional antenna hooked into their antenna circuit.

Sitting on top of the worldwide transceiver is a dual-band mobile or handheld transceiver that will act as the transponder to your little dual-band handheld. The base transponder system could be the little handheld TH-D7A or TH-79 KSS, or the new Kenwood mobile TH-D700A dual-bander. These three transceivers have built-in capabilities for radio remote control, as well as capabilities to read out digital information as a datastream. I suggest the new Kenwood TH-D700A dual-band mobile to be the transponder because one side of your high-frequency radio circuit is constantly transmitting out to your little portable handheld. If you plan to run much power over a longer-than-usual separation, the mobile would run cooler longer.

Your little handheld is the Kenwood TH-D7A, straight out of the box, or the popular Kenwood TH-79, KSS version, dual-band portable. Your friends will think you just have a nice little dual-band ham set, or may mistake it for a simple cellular phone. Wait until they hear what comes out of your speaker!

The whole idea behind this system was put together by well-known ham manufacturer Kenwood Corporation.

At our Radio School weekend licensing classes, the typical set-up would be our communication's van parked outside of the classroom, and a wireless VHF/UHF connection to the worldwide Kenwood radio on the inside of the van, hooked up to an extensive high-frequency mobile multi-band antenna system. Or, if I'm just going to run on a single band, I will pre-set the Outbacker Outreach for the particular band of operation.

Next, I turn on the mobile system by the on/off buttons and make sure that the intended VHF/UHF full duplex frequencies are clear of any local traffic. I usually operate with extremely small antennas to keep the system "localized" to within a few blocks of the classroom.

Inside the classroom, I turn on the Kenwood TH-D7A, dial in my UHF transmit frequency which corresponds to the UHF receive frequency in the van. The "talk back" of all the high-frequency signals from the van goes over the two-meter band, and this I tune in on receive on the two-meter side of the TH-D7A. When I transmit, I establish the link, and I first give my call sign to cover the UHF operation on a frequency that is coordinated for remote base use. And since I'm running just a fraction of a watt, chances are no one beyond a couple of blocks will even know I'm on the air.

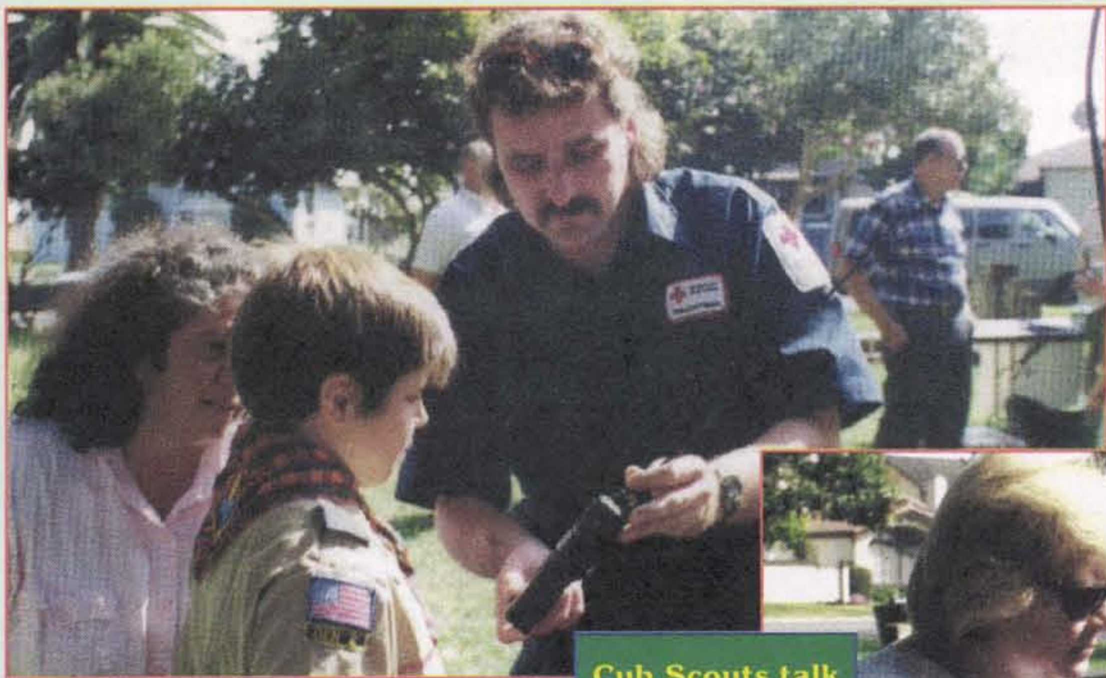
I keystroke specific DTMF numbers to bring the high-frequency system up so it is transmitting back to me simultaneously on two meters. Again, the two-meter link is extremely low power and localized to within just a couple of blocks of our classroom and vehicle location. I keystroke the automatic CW ID to properly identify the two-meter talk back.

To find out where I am on the radio dial, I can push a single button to enable the voice synthesizer to speak my high-frequency setting, or even command my high-frequency Kenwood to output a data burst to the 450MHz link so I can actually see the frequency on my little TH-D7A handheld. Keep in mind that this Kenwood handheld is the same one that can read packet radio, too!

Now I can keystroke myself up or down frequency, looking for activity. I'm operating full duplex, so I can instantly stop anywhere I want to on the band, press one additional button to prepare the transmitter to accept my handheld side of the conversation, and then join in on the conversation when the two distant stations ask for more check-ins. The actual key tones are muted so the distant stations really won't hear that I have come up on their frequency and will be joining the conversation. In fact, if I operate my handheld and transponder VHF/UHF radio with full CTCSS enabled, they won't hear a squelch tail either!

You can imagine the surprise of these two stations when I tell them I am talking to them inside a classroom several hundred feet away from my vehicle over a handheld 440/two-meter link radio. And you can imagine the excitement created in the classroom when students are hearing stations thousands of miles away talking to me over the little handheld.

It gets better – I can then snap some electronic photos with the Kenwood VC-H1 visual communicator, and then send these photos to other stations throughout the world. They can also send me photos, and I can see them right on



Cub Scouts talk to New York on the Kenwood radio remote system.

the screen of the companion VC-H1 visual communicator.

Best of all, when I work the City of Costa Mesa and Orange County Chapter of the American Red Cross emergency nets on worldwide, I don't need to be sitting right there at the driver's seat in the van to go over the high-frequency airwaves. I can take high frequency with me, radio remotely, simply by turning on my dual-band handheld, and walking away from the vehicle. As long as I am within VHF/UHF range of the vehicle, I am still on the air over HF. In case I stray too far away, the HF link may ultimately give my call sign, and shut off to conform to the FCC rules.

One aspect of the amateur radio rules is "technical investigation." And this is exactly what this type of operation is when you scour the rules and try to analyze the difference between remote base, radio control, cross-band repeat, ID, links, time-out timers, and all other aspects of Part 97. If this system is operated with low power on unused frequencies with localized antenna systems, it should blend in nicely with the overall ham radio frequency use and band plans for that specific region.

You would want to start out this system using extremely low power and zero gain antennas to confine your signals within a few hundred feet or a mile or so from your radio remote high-frequency station. But once you begin to blend in with the activities in your area, your station could offer capabilities to other hams in the vicinity to make use of it, too. And if widespread emergencies should hit, it could allow many handheld communicators to send signals through an HF base station to a regional amateur radio emergency network. Although some hams have "home brewed" their own high-frequency remote base system with a dual-band handheld, Kenwood Corporation has taken all of the guess work out of putting together such a station and has specifically designed specific pieces of equipment and a special interface cable to make this entire set-up almost "plug-and-play."

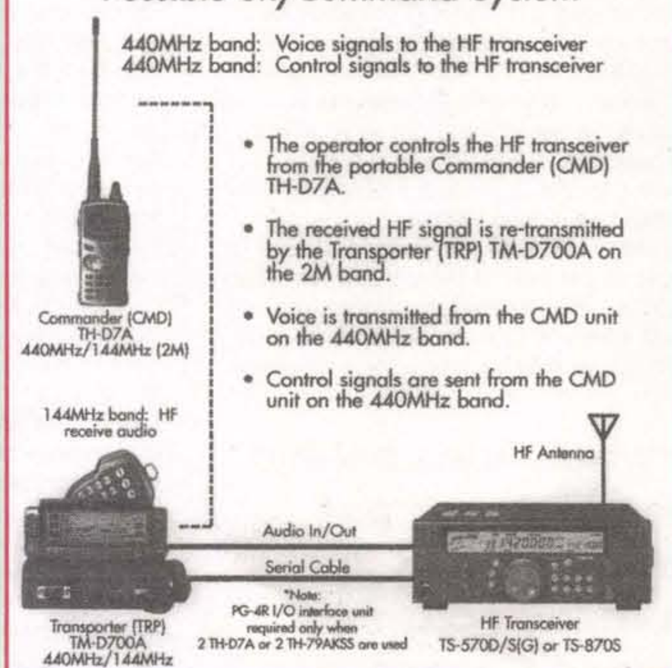
For a technical review of how this full duplex UHF to HF and HF to VHF system works, visit the Kenwood web site at www.kenwood.net and download Sky Command System details from the operator's manual in PFD format. Or, if you want to talk to someone at Kenwood to further discuss the capabilities of the Sky Command System using Kenwood equipment, call 310-639-5300.

Amateur operators are viewing this "plug-and-play" system as a major benefit in working worldwide with their new 5 wpm privileges when living in an area that may not allow roof-top antennas.

Just park your vehicle in front of your home or office, turn on the HF radio inside your vehicle, and you may be all set to work the world remotely. But keep one thing in mind – if you gab all night, you could very well run your battery down in the vehicle, and you're going to be a little late to work the next morning!

The Kenwood system is terrific, and I have tried it personally at our Radio School, as well as in our emergency communication van. **NV**

Possible SkyCommand System



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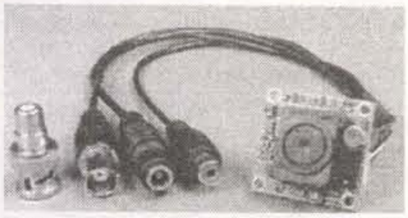

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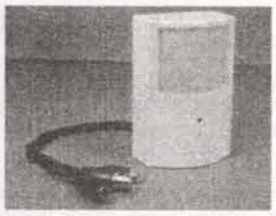

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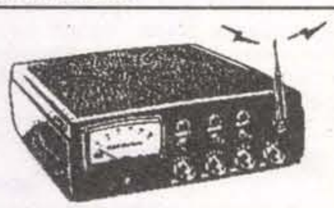

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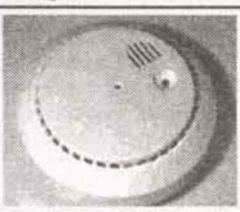

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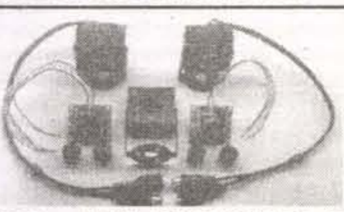

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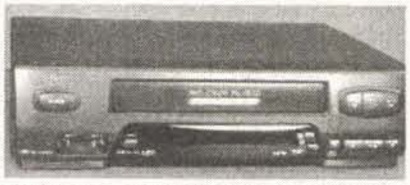

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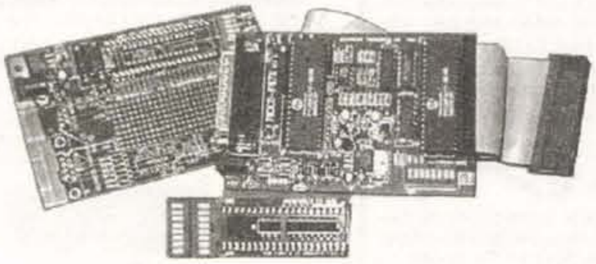

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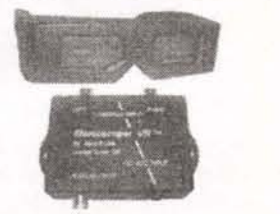

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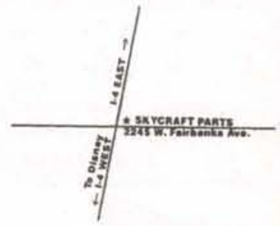

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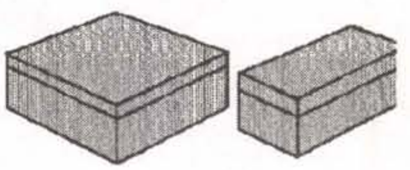

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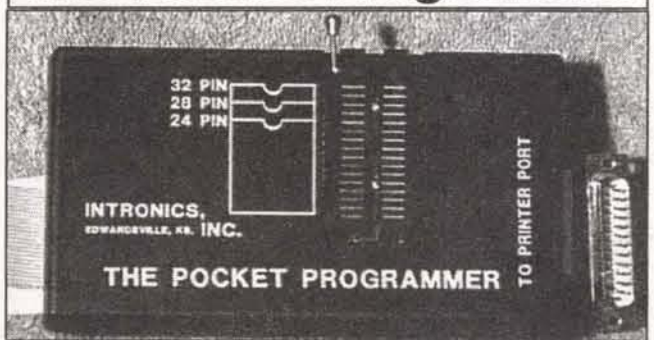

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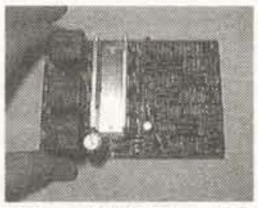

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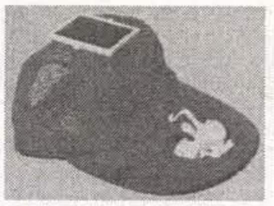

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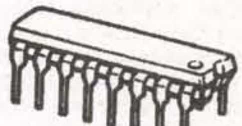

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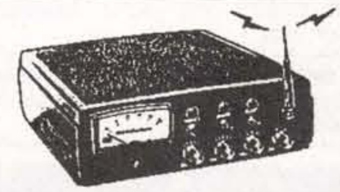

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Continued on page 80

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

Whenever I'm confronted for the first time with a system of seemingly unmanageable complexity, I try to break it down into smaller parts. I believe that if you can classify something — or at least parts of it — you are on your way toward understanding the system as a whole.

This has special relevance to me these frenzied days — just one week until closing! — as I pack for the move to our new house. I'm distilling our family possessions into 70 numbered 14-inch-square boxes and a dozen larger boxes (with a half dozen objects left over, too large or oddly-shaped to fit into any box smaller than a moving van). All this classification is really giving me a handle on what our lifestyle has been, and how distressingly obsolete much of it now is.

For instance, I almost certainly will never do another microprocessor project with an NMOS 8085, yet I have several of them in my IC box. I even came across my old slide rule from junior high school. (A slide rule is a mechanical analog computer, for those of you who've never heard of them, and it's what we used to calculate "good enough" numbers before the advent of pocket calculators. Really.)

Probably the biggest realization I've had, though, is that packing for the tightest fit, as I did three years ago for my move from Seattle to Pittsburgh, is nowhere near optimum for ease of later finding things — despite having done rough inventories for each box.

This time, I'm packing all my analog engineering design books in one box, and not worrying about the "wasted" space. Likewise, all the digital stuff is going in one box, all my robotics books in another, and so on. The boxes are not getting packed as quickly this time around, nor as full, but I'll be able to find stuff.

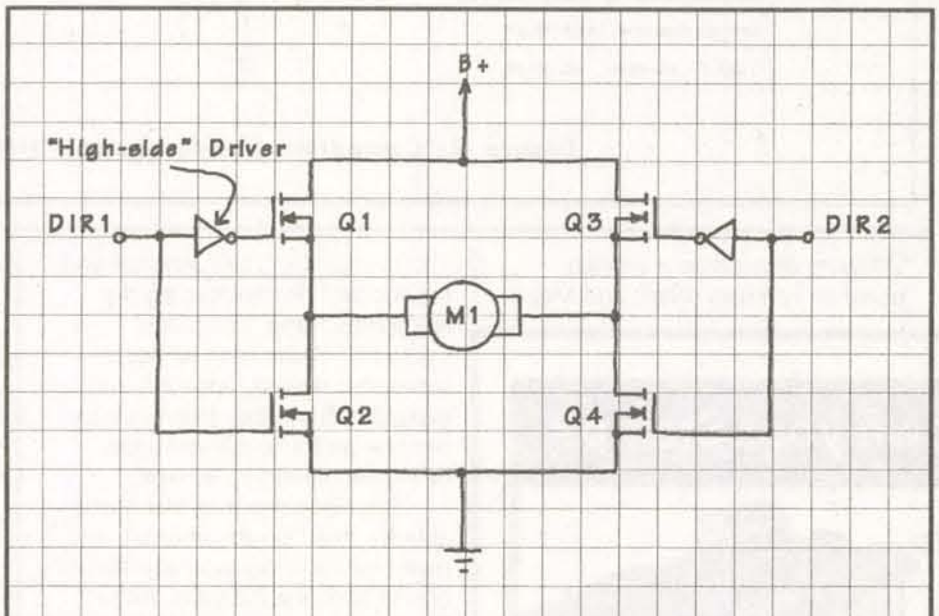

Figure 1: H-bridge using N-Channel MOSFET

The Zen of Packing

What does all this have to do with amateur robotics? Nothing, really, except I've had lots of time to think about robots I can make from all the parts I've been packing and, in the general reshuffle, I've come across a couple books I've been meaning to review in this column.

Those of you who've been reading this column for a while know I'm interested in the phenomenon of Linux and Open Source Software development. I built my own Linux box a while back, though I'm still not very good at Linux.

Yonatan, my one-year-old son, is learning to walk amid the boxes, and my main job description has changed from "feeding, cleaning, and cuddling the boy" to "saving the boy's life" on a daily basis. When I'm not packing, I'm rescuing Yonatan from the latest fix he's gotten himself into. Or planning how to prevent him from getting into even more serious fixes. (Someday, once the trauma has worn off, I'll tell y'all about the bottle of Pedialyte that recently wound up costing us $8,000.00. The things I do for that boy.) Anyway, I haven't had much time left over for hacking Linux.

But I have had time for reading, and this month I have two recommendations for books about the whole Open Source thang (of which Linux is a prominent example). And since my life is upside down already, I'll lead with the book reviews.

Voices from the Revolution

The first book is *Open Sources: Voices from the Open Source Revolution* (O'Reilly & Associates, 1999, $24.95 US). *Open Sources* is an anthology of essays, broadsides, and debates on the meaning, definition, and nature of Open Source Software. With 14 different authors weighing in, the views run the gamut from "Information wants to be free!" (Richard Stallman, of EMACS and GNU fame) to "How can I make a buck on this?" (Bob Young, Red Hat Software).

You'll also find a couple articles by Eric S. Raymond (the unofficial ethnographer of Hacker Culture and guerrilla philosopher of the modern Open Source Software movement); Linus Torvalds on, well, Linux; and Larry Wall with an amusing series of koans on why Perl is the One True Scripting

Language.

There are tidbits of hacker history, histories of the Free Software and Open Source movements, and even transcripts of the infamous Tanenbaum-Torvalds "Linux is obsolete" e-debate.

I thoroughly enjoyed this book and recommend it to anyone who is trying to come to grips with exactly why people would ever want to give away the source code they've labored so hard to produce. At $24.95 for the trade paperback edition, it is a bit pricey, but I found it worthwhile – if only to contrast the views of Richard Stallman with those of Eric S. Raymond.

Echoes in the Cathedral

The second book is *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary* (O'Reilly & Associates, 1999, $19.95 US) by, who else, Eric S. Raymond. I snapped up the hardcover the instant I saw it in the bookstore because I'm such a big fan of Raymond's writings. In this book, collected are his classic FAQ "How to Become a Hacker," his 1992 "A Brief History of Hackerdom," and his seminal articles on Open Source Software development written between February 1996, and May 1999 – namely "The Cathedral and the Bazaar," "Homesteading the Noosphere," and "The Magic Cauldron." These have all been somewhat revised, updated, and expanded from their Internet incarnations, and a couple extra bits have been stirred in, as well.

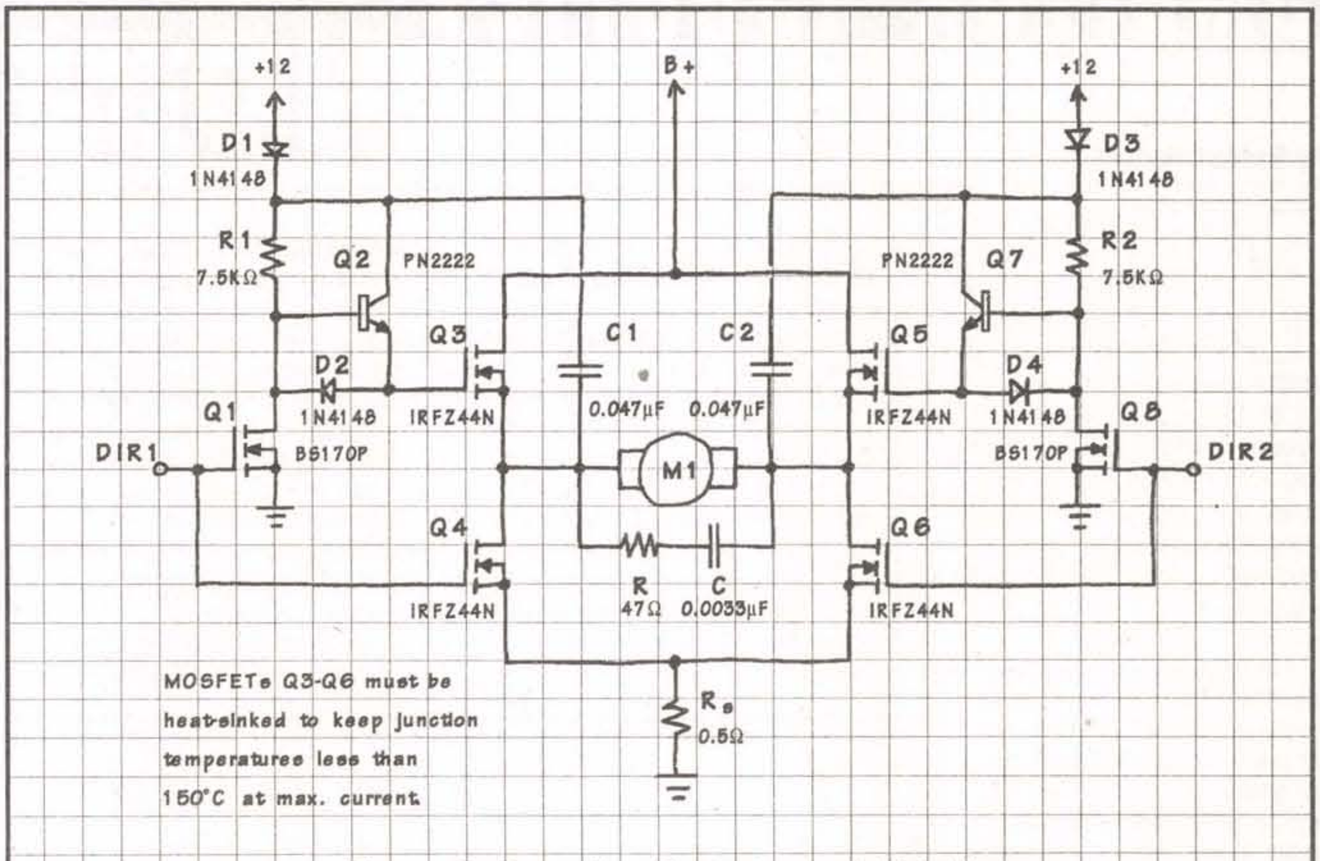

Figure 2: Capacitor Boot-strapped H-bridge

Still, since much of this is available for "free" on the Internet, you might well wonder why you should go out and buy the book. Indeed, I'd already read these articles as they appeared on the net, yet I bought the book anyway. I bought it because, first of all, it's handy to have them all collected into one place in such an easy-to-read format. I hate reading long texts on screen, and loose sheafs of laser-printed pages aren't much better. It was worth it to me to have them all bound up in one neat volume. E-books will have to come a long way before they match the user-friendliness of plain old ink-on-paper bound books.

Second, I bought the book because I believe in the cause and method behind Open Source Software, and I believe in putting my money where my mouth is. If we are ever to have mobile robots with software reliable enough to interact with humans in the real world, I am certain it will be because the software infrastructure behind the robot will be Open Source.

With Open Source Software, the source code of the OS and all the myriad device drivers can be examined, tested, and hacked by thousands of "amateurs" whose only unifying passion is the building of working robots. As Raymond says, "Given enough eyeballs, all bugs are shallow." If you get no other book this year on the process of software development, this is the one to get.

(Fair warning: two items in this volume, "A Brief History of Hackerdom" and "The Revenge of the Hackers" also appear in Open Sources.)

Now, let's get to more specifically robot-related stuff.

Robotics is another field where divide-and-conquer classification can help bring about understanding. Amateur robotics is far from being a homogeneous field, and it can be quite daunting to the beginner to sort everything out – or even to know where to begin. Years ago, a member of the Robot Society of Southern California showed me one classification scheme for mobile robots which I still find useful today. In ascending order of complexity and capability, they are:

Tethered Robots

Tethered Robots are like the electrically operated puppets used in special effects work. They are the simplest place for a beginner to start in robotics. There was a time when most so-called "Remote Control" toys were wire-controlled toys. They are still around at places like RadioShack and Toys R Us, but they are far outnumbered by true

radio control toys nowadays.

A cheap RC toy can still be used as a tethered robot merely by ripping the RC receiver out and replacing it with a bunch of switches and wires to make the motors go. In doing this, the beginner quickly learns basic wiring practices and how to drive and reverse motors. Every motor will need two wires, plus you'll need two wires for B+ and Ground (B-).

The second step might be to use the switches to control transistors or relays located on the robot so that motor currents don't flow in the control tether; you could use any of the motor driver circuits described in this series on motor control. You can then use lighter gauge, more flexible wire for the control tether.

For tethered robots with more than, say, four functions to control, the sheer number of wires needed for the tether makes it unwieldy, so you can go the next logical step by replacing the parallel tether wires with a serial cable. You might do this with a shift register at each end: a parallel-to-serial shift register to turn the switch data into a serial bit stream, and a serial-to-parallel shift register to convert the bit stream back to into parallel outputs at the robot end. Those parallel outputs would drive the transistors which drive the motors, as in the tethered robot.

A more sophisticated version could use Universal Asynchronous Receiver/Transmitter (UART) chips to perform the same function, allowing full-duplex operation. With a UART, it becomes possible to use the RS-232 serial port of a PC to directly control your robot and, with sensor feedback, you now have the start of a fully autonomous 'bot (except it's tethered to your computer).

Of course, you can replace the UARTs with a microcontroller, and you could also replace the RS-232 with an I2C interface. (I really will finish the I2C Master code someday, folks. Honest.)

Telerobots

Teleoperated Robots or Telerobots are remote control robots. They do jobs like nuclear power plant maintenance, pipe/ductwork inspection, and undersea exploration, to name a few. For these jobs, telemetry information such as video, temperature, pressure, radioactivity, or force feedback is vital for the person controlling the telerobot.

Strictly speaking, ordinary model RC cars, planes, and boats shouldn't be called telerobots because they don't provide this telemetry feedback to the user. With ingenuity, though, you can add video cameras, bumper sensors, and the like to stock RC models. This can be a great way to teach yourself how industrial telerobots work.

Supervised Autonomous

Some amateurs have even devised video and control signal delay systems to explore the problems involved in controlling telerobots from great distances, such as from the earth to the moon. Earth/moon round-trip travel time for radio signals is about 2.5 seconds, making direct control impractical. This means the robot can't be just a radio-controlled puppet, but must have some intelligence on board. These are called Supervised Autonomous (SA) robots, the third major class of mobile robots. The plucky Mars Sojourner was a great example of a supervised autonomous robot.

SA robots not only have uses in space, but also in undersea exploration where radio signals can't penetrate. In the ocean depths, control and feedback must travel as sound waves, so several seconds can elapse between sending a command and receiving confirmation from the robot sub. The robot must have enough on-board intelligence to carry out commands and stay out of trouble.

Today, amateurs can contribute directly to robotics research by experimenting with SA robots such as submersibles. When we return to the moon this century, amateurs will have also helped pave the way for lunar SA robots with their experiments here on earth.

Autonomous Robots

Autonomous Robots, the fourth category, are the sort we normally think of when we talk about robots. Truly autonomous robots do exist, but only for carefully controlled and specified environments.

It is your task as an amateur robot builder to work your way through these successively more difficult robots, solving problems and honing your skills. By the time you're ready to work on fully autonomous robots, you will not only have learned what it takes to build robots, you will have earned your place at the cutting edge of robotics.

Back to the Trailing Edge

Basic motor control is decidedly not leading-edge robotics, but it's the foundation on which mobile robotics is built, so now we'll get back to more motor driver circuits.

Last time, I showed two simple solid-state versions of H-Bridge motor drivers. One used complementary PNP and NPN bipolar transistors in a push-pull Emitter Follower configuration; the other used complementary N- and P-Channel power MOSFETs in a Common Source configuration. The Common Source topology works fine, but P-Channel MOSFETs are two to three times the cost of their N-Channel complements. It makes sense to ask if an H-Bridge could be built using only N-Channel MOSFETs for both the high- and low-side switches.

The answer is yes, but there are complications.

You could just make a straight substitution of N-Channel MOSFETs (connected Common Drain) for the high-side P-Channel MOSFETs (connected Common Source). You would drive the low-side gate as before, but the high-side MOSFET gate would have to be driven with an inverted version of the low-side gate signal (see Figure 1). The circuit is a little more complex than the complementary power MOSFET circuit from last month, but since inverters are quite cheap compared to P-Channel power MOSFETs, this would seem a good tradeoff.

The problem with this circuit is that the high-side MOSFETs never get enough enhancement voltage to turn fully ON, even when driven by CMOS devices that swing all the way between ground and B+. To see why, consider that the voltage on the source of the high-side MOS-

FET will be zero when Q1 is OFF and Q2 is ON. Keep DIR2 tied high so Q4 will always be ON.

Now, as soon as you apply a low level to DIR1, Q1 begins to turn ON, Q2 turns OFF, and current begins to flow through Q1 into the load. As the voltage across the load ramps up, the relative voltage from gate to source of Q1 will drop, increasing Q1's ON resistance until an equilibrium is established with Q1 dropping part of the voltage and the load taking what's left over.

The Common Drain topology prevents the source of Q1 from approaching closer than a few volts of the gate voltage – B+ – so the voltage seen by the load will always be less than B+ by this amount. The motor won't run at full speed, and the high-side MOSFET will dissipate more power. To turn Q1 fully on so that the motor receives most of the B+ voltage, the high-side gate must be driven with a voltage higher than B+ – from 5 to 12 volts higher – depending on the MOSFET.

By the Bootstraps

There are many ways to derive this higher voltage, including inductive bootstraps, capacitive bootstraps, separate power supplies, transformer isolation, and purpose-designed high-side driver chips. These all come down to doing DC-DC conversion to derive a voltage supply (or voltage pulses) higher than B+ to drive the high-side gate. They also involve some kind of level translation to allow controlling that higher voltage with TTL logic level signals.

Some circuits use optoisolators to isolate high-side drive circuitry from logic level inputs. High-side drivers simply package the DC-DC convertor and logic-level translation into one convenient chip. I'll revisit high-side driver chips in a future column.

This month, I'll talk about the Capacitor Bootstrap method, as shown in Figure 2. This circuit is quite a bit more complicated than the complementary MOSFET H-Bridge, but the extra components are cheaper than P-Channel parts. The extra circuitry also performs input level translation so the driver can operate from five-volt logic level inputs, unlike all of the previous H-Bridges in this series.

To see how this circuit works, assume that both DIR1 and DIR2 are initially logic level high. Both low-side MOSFETs, Q4 and Q6, will be biased ON and will pull the motor leads and the source connections of the high-side MOSFETs (Q3 and Q5) to ground potential. Q1 and Q8 will also be ON, pulling the gates of Q3 and Q5 low through diodes D2 and D4, respectively, thus biasing Q2 and Q7 OFF. After the circuit has remained in this state long enough for transients to die down, the two bootstrap capacitors, C1 and C2, will have fully charged to one diode drop below B+ through D1 and D3.

Now, if we bring DIR1 low and leave DIR2 high, Q1 and Q4 will immediately turn OFF. Q1 turning OFF allows resistor R1 to bias Q2 ON, providing a low impedance path to start the gate of Q3 charging through D1. This is the level translation function of the circuit at work.

As the gate of Q3 charges, its gate-source voltage rises and Q3 begins to conduct. As with the H-Bridge in Figure 1, the voltage across the motor ramps up at the source of the high-side MOSFET, but unlike in the former circuit, the relative gate-source voltage, in this case, remains constant as C1 retains most of its charge. As Q3's source voltage rises, C1 forces the collector voltage of Q2 to rise above B+, causing D1 to reverse bias. This isolates Q2's collector from the B+ supply and allows C1 to deliver a portion of its charge through Q2 to the gate capacitance of Q3.

Rule of 10

As a rule of thumb, the bootstrap capacitor must have a capacitance at least 10 times the gate capacitance of the MOSFET to ensure the bootstrap has enough charge to bring the gate to its voltage.

If the circuit is left DIR1 low long enough (many seconds), the charges on both the bootstrap and the gate will leak away, the gate-source voltage of Q3 will diminish, and eventually we'll be right back to the situation of the circuit in Figure 1.

But, if we drive this circuit with a PWM signal with a period much shorter than the charge decay time, the bootstrap voltage will stay practically constant.

What happens when the PWM signal on DIR1 goes high again? First, Q1 and Q4 will turn ON. Q1 discharges the gate of Q3 through D2, turning Q3 OFF. At the same time, Q1 biases Q2 OFF, isolating C1 and thus allowing it to retain its charge until the cycle repeats.

Heatsinks are Cool

The circuit as presented can handle many amps of motor current. The IRFZ44 MOSFETs have a minimum ON resistance of 0.024 ohms, and even at their peak current rating of 160 amps, they would drop less than a volt each. With proper heatsinking, you could push this circuit out to 41 amps continuous. Note that for high performance circuits, heatsinking is critical – not just to keep the MOSFETs from burning up, but to keep their ON resistances low. Unlike bipolar transistors, the ON-resistance of a MOSFET increases with temperature; the better the heatsink, the lower the junction temperature, and the more current the MOSFET will handle.

One obstacle to getting the full-rated current out of this circuit turns out to be, paradoxically, the fact that the low-side MOSFETs Q4 and Q6 won't turn on fully with just a TTL logic level driving their gates. This problem can be solved a number of ways, but the most direct would be to drive DIR1 and DIR2 with open-drain or open-collector outputs with pull-up resistors to +12V. (I haven't tried this because I don't have a robot with motors that draw anything like 41 amps ... yet!)

One more box to pack ...

Actually, it's closer to 30 more boxes at this point. I will be back next month, bloodied but not beaten. Next time, I'll take a look at some integrated H-bridge ICs that really pack a lot of power handling capability into small packages and maybe talk a bit about standard robot interfaces. **NV**

Please note that my contact information is now different. If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

Robert Nansel
Box 228
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The E-Mail address is the same:
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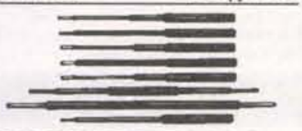

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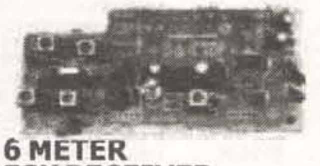

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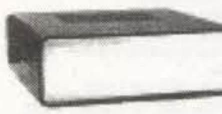

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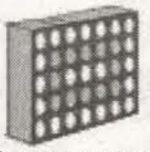

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- HP 6271B 0-60 V 0-3 A CV/CC Power Supply — $375.00
- HP 6274B 0-60 V 0-15 A CV/CC Power Supply — $650.00
- HP 6282A 0-10 V 0-10 A CV/CC Power Supply — $200.00
- HP 6289A 0-40 V 0-1.5 A CV/CC Power Supply — $200.00
- HP 6299A 0-100 V 0-750 mA CV/CC Power Supply — $200.00
- HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply — $125.00
- HP 6443B 0-120 V 0-2.5 A CV/CC Power Supply — $450.00
- HP 6652A 0-20 V 0-25 A 500 Watt Programmable Power Supply, HPIB — $1,875.00
- KEPCO ATE 36-30M 0-36 V 0-30 A CV/CC Power Supply — $900.00
- KEPCO ATE 36-8M 0-36 V 0-8 A CV/CC Power Supply — $375.00
- LAMBDA LK-352-FM 0-60 V 0-15 A CV/CC Power Supply — $600.00
- SORENSON DCR 150-3B 0-150 V 0-3 A CV/CC Power Supply — $500.00
- SORENSON DCR 600-0.75B 0-600 V 0-750 mA CV/CC Power Supply — $550.00
- SORENSON DCS 40-25 0-40 V 0-25 A CV/CC Power Supply — $650.00
- SORENSON SRL 20-12 0-20 V 0-12 A CV/CC Power Supply — $400.00
- SORENSON SRL 60-8 0-60 V 0-8 A CV/CC Power Supply — $600.00
- TEK PS501-1 Power Supply, 0-20 V, 2 mV res., 400 mA, TM500 series — $175.00

MULTIPLE OUTPUT

- HP 6205C Dual Power Supply, 0-40 V 300 mA & 0-20 V 600 mA, CV/CL — $300.00
- HP 6228B Dual 0-50 V 0-1 A CV/CC Power Supply — $400.00
- HP 6236B Triple Output Power Supply, +/- 0-20V 0.5A & 0-6V 2.5A — $375.00
- HP 6253A Dual 0-20 V 0-3 A CV/CC Power Supply — $400.00
- HP 6255A Dual 0-40 V 0-1.5 A CV/CC Power Supply — $400.00
- KEPCO MPS-620M Triple Output Supply, dual 0-20V 1A tracking & 0-6V 5A — $250.00
- LAMBDA LPT-7202-FM Triple Output Power Supply — $450.00
- TEK PS5010 Programmable Triple Power Supply, TM5000 series — $650.00
- TEK PS503A Dual Power Supply, TM500 series — $200.00

MISCELLANEOUS

- ACME PS2L-500 Programmable Load, 0-75 V / 0-75 A / 500 Watts max. — $350.00
- ELGAR 501C/400SD AC Power Source, 45 Hz-5 kHz, 500 VA, 0-135 VAC — $1,150.00
- HP 59501B HPIB Isolated DAC/Power Supply Programmer — $175.00
- HP 6060A 300 Watt Programmable Load, 0-60 A / 3-60 V, HPIB — $950.00
- KEPCO BOP 20-20M Bipolar Op Amp/Power Supply, to 20 V 20 A — $675.00
- KEPCO BOP 50-2M Bipolar Op Amp/Power Supply, to 50 V 2 A — $400.00
- TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max. — $200.00

TIME & FREQUENCY

UNIVERSAL COUNTERS

- HP 5314A-001 100 MHz/100 nS Universal Counter; TCXO reference option — $250.00
- HP 5315A 100 MHz/100 nS Universal Counter — $350.00
- HP 5315A-002,003 100 MHz/100 nS Univ. Counter; batt. power & 1 GHz C-ch. — $550.00
- HP 5315A-003 100 MHz/100 nS Univ. Counter, 1 GHz C-channel option — $450.00
- HP 5315B 100 MHz/ 100 nS Universal Counter — $375.00
- HP 5316A 100 MHz/100 nS Universal Counter, HPIB — $450.00
- HP 5316A-001,003 100 MHz/ 100 nS Univ. Counter, HPIB, TCXO, 1 GHz C-ch. — $600.00
- HP 5316B 100 MHz/ 100 nS Universal Counter, HPIB — $550.00
- HP 5335A-10,30,40 200 MHz/2 nS Universal Counter, OCXO ref., 1.3 GHz C-ch — $950.00
- HP 5370A 100 MHz/ 20 pS 11 digit Universal Time Interval Counter — $750.00
- HP 5370B 100 MHz/ 20 pS Universal Counter, 11 digits — $1,200.00
- PHILIPS PM6672/411 120 MHz/100 nS Universal Counter, C-channel 70-1000 MHz — $450.00
- TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series — $250.00
- TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series — $400.00
- TEK DC5010 350 MHz / 3.125 nS Universal Counter, TM5000 series — $950.00
- TEK DC503A 125 MHz/100 nS Universal Counter, TM500 series — $275.00
- TEK DC509 135 MHz/ 10 nS Universal Counter, TM500 series — $275.00

FREQUENCY COUNTERS

- EIP 545A 18 GHz Frequency Counter — $750.00
- FLUKE 7220A-010,131,351 1.3 GHz Counter; battery power, OCXO, and res. mult. — $500.00
- HP 5340A-002 18 GHz Frequency Counter, rear panel input — $450.00
- HP 5342A 18 GHz Frequency Counter — $1,250.00
- HP 5343A-001 26.5 GHz Frequency Counter, OCXO reference — $3,000.00
- HP 5343A-001,011 26.5 GHz Frequency Counter, OCXO reference, HPIB — $3,500.00
- HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter — $3,500.00
- HP 5351B-001 26.5 GHz Frequency Counter, HPIB, OCXO reference — $4,250.00
- HP 5364A Microwave Mixer / Detector, for modulation domain an. — $3,000.00

STANDARDS

- HP 105B Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz, battery power — $1,100.00
- HP 5087A-opt.032 Distribution Amplifier, 12 outputs at 5 MHz — $1,750.00

AUDIO & BASEBAND

SPECTRUM ANALYSIS

- HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms — $1,200.00

DISTORTION ANALYZERS

- HP 334A Distortion Analyzer, 5 Hz-600 kHz, 0.06% THD — $375.00
- HP 8903A Audio Analyzer, 20 Hz-100 kHz — $1,200.00
- HP 8903B-001 Audio Analyzer, 20 Hz-100 kHz; rear input option — $1,650.00

RMS VOLTMETERS

- FLUKE 8922A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz — $450.00

OSCILLATORS

- HP 3336C-004,005 21 MHz Synthesizer/ Level Gen., OCXO & hi accuracy att. — $1,400.00
- TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten.,TM500 — $200.00
- HP 3575A-002 Phase-Gain Meter, 1 Hz-13 MHz, dual display — $850.00
- HP 461A Amplifier, 20 dB or 40 dB gain, 1 kHz-150 MHz — $125.00
- HP 467A Power Amplifier, X1/X2/X5/X10, DC-1 MHz, 10 W output — $375.00
- KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave — $350.00

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PRACTICAL LED INDICATOR AND FLASHER CIRCUITS

by Ray Marston

Next month, Ray will present a selection of practical 4017B-based LED chaser or sequencer circuits.

Ray Marston describes a variety of LED indicator and LED flasher circuits in this special feature article.

Figure 1. **Standard LED symbol, together with its terminal notations.**

INTRODUCTION

The most widely used of all optoelectronic devices is the simple LED (light emitting diode), which emits a fairly narrow bandwidth of visible (usually red, orange, yellow, or green) or invisible (infrared) light when its internal diode junction is stimulated by a forward electric current.

LEDs have typical power-to-light energy conversion efficiencies some 10 to 100 times greater than a simple tungsten filament lamp and have very fast response times (less than 0.1µS, compared to 10s or 100s of milliseconds for a tungsten lamp), and are thus widely used as visual indicators and as simple 'flashing light' units. A variety of such circuits are shown in this article.

LED BASICS

INTRODUCTION

Figure 1 shows the standard symbol that is used to represent an LED in this article, together with its basic anode (a) and cathode (k) terminal notations.

LEDs are *pn* junction diodes, usually made from gallium arsenide (GaAs) or aluminum-gallium arsenide (AlGaAs) types of semiconductor materials, and emit light when stimulated by a forward current.

COLOR	Red	Orange	Yellow	Green	Blue
V_f (typical)	2V	2V	2.1V	2.2V	3.3V

Figure 2. **Typical forward voltage values of standard LEDs at a current-limited value of 20mA.**

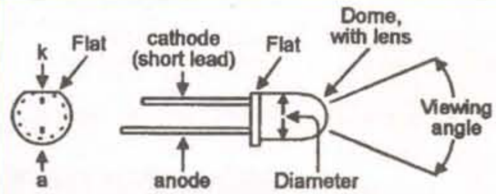


Figure 3. **Typical physical details of 'round' LEDs and methods of recognizing their polarity.**

LED Type	Viewing Angle	Red	Green	Orange
Standard	60°	7mcd	5.2mcd	8mcd
High Brightness	40°	30mcd	25mcd	50mcd
Super Bright	30°	125mcd	120mcd	140mcd
Ultrabright	25°	1000mcd	—	—
Hyperbright	25°	3500mcd	—	—

Figure 4. **Typical optical output power figures — in millicandelas — of five basic types of 5mm round red, yellow, and green LEDs.**

Roughly 2V are developed across them when passing a useful forward current; *Figure 2* lists the typical forward volt drops (Vf) of different colored standard 5mm diameter LEDs at forward currents of 20mA.

If an LED is reverse-biased, it starts to pass significant current at a fairly low voltage value (typically 3V to 5V) and eventually avalanches (zeners) at higher voltages.

LEDs are available in a variety of styles, the most popular being the 'round' type that has the basic shape shown in *Figure 3* and which is readily available in standard diameter sizes of 3mm, 5mm, 8mm, or 10mm. Round LEDs use a clear or colored plastic case with a lens molded into its dome, and are designed to be viewed end-on, looking towards the dome, as indicated in the diagram.

The LED case has a polarity-identifying 'flat' molded into the side of its base adjacent to the cathode lead, which is usually shorter than the anode lead when untrimmed. Special fittings are readily available for fixing most sizes of LED to front panels, etc.

One important but confusingly-

PRACTICAL LED INDICATOR AND FLASHER CIRCUITS

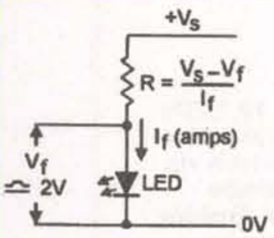


Figure 5. **Method of finding the R value for a given V_S and I_f.**

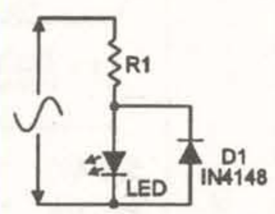


Figure 6. **Using an LED as an indicator in an AC circuit.**

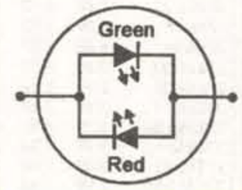


Figure 8. **Bi-color LED actually houses two LEDs connected in inverse parallel.**

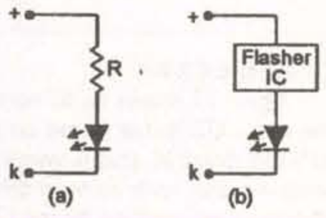
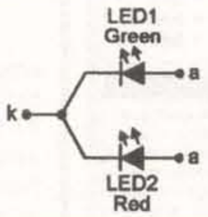


Figure 7. **Basic form of a direct connection DC LED (a) and a flasher LED (b).**



Output colour	Red	Yellow	Green
I, LED1	0	15mA	15mA
I, LED2	15mA	15mA	0

Figure 9. **Multicolor LED, giving three colors from two junctions.**

named LED parameter is its 'viewing angle,' at the extremes of which the LED's optical output intensity falls to half of its maximum axial value. Some LEDs give a diffused output in which the light intensity falls off gradually beyond the viewing angle and is thus clearly discernable over a wide angular range; others (particularly 'Hyperbright' types) have a sharply focused output in which the light intensity falls off very sharply beyond the specified viewing angle.

LEDs are available in five different 'brightness' categories, which are usually known as Standard, High Brightness, Super Bright, Ultrabright, and Hyperbright. The brightness level is usually specified in milli-candelas (mcd), with the LED passing an operating current of 20mA. The table in *Figure 4* presents typical optical output-power and viewing-angle figures for the five types of 5mm round LED. Note in the 'red' LED column that the Ultrabright and Hyperbright devices (which use water-clear lenses) are 143 and 500 times brighter, respectively, than a standard red LED.

In use, an LED must be wired in series with a current-limiting device such as a resistor. *Figure 5* shows how to work out the resistance (R) value needed to give a particular current from a particular DC supply voltage. Thus, if a red LED is required to operate at 20mA from a 10V supply, R needs a value of (10V - 2V)/0.02A = 400R. In practice, R can be connected to either the anode or the cathode of the LED.

A LED can be used as an indicator in an AC circuit by wiring it in inverse parallel with a IN4148 (or similar) silicon diode, as shown in *Figure 6*, to prevent the LED from being reverse-biased; the LED is fed with a half-wave current in this mode, so — for a given brightness — the 'R' value must be halved relative to that indicated in the *Figure 5* DC circuit.

SPECIAL-PURPOSE LEDs

LEDs are readily available in a variety of special-purpose forms, the best known of which are the 'direct connection' type, the 'flasher' type, and the multicolor types.

Direct connection LEDs are designed to be connected directly across a fixed-value DC or AC voltage source. DC voltage types take the basic form shown in *Figure 7(a)* and incorporate a current-limiting resistor that is housed in the LED body in 5V and 12V types, or in one of the LED leads in higher voltage types. AC voltage types (usually designed for use with 110V or 240V supplies) take the basic form shown in *Figure 6*, but are usually housed in an insulated panel-mounting assembly.

Flashing LEDs take the basic form shown in *Figure 7(b)* and have a built-in integrated circuit that gives the flashing effect. They are available in red, green, and yellow, have a typical flashing frequency of 2Hz, and can (typically) use 6V to 12V DC supplies.

Multicolor LEDs are actually two-LED devices. *Figure 8* shows a 'bi-color' device that comprises a red and a green LED connected in inverse parallel, so that the color green is generated when the device is connected in one polarity, and red is generated when it is connected in the reverse polarity. This device is useful as a polarity or null indicator.

Figure 9 shows another type of multicolor LED, which is sometimes known as a 'tri-color' type. This comprises a green and red LED mounted in a three-pin common-cathode package. This device can generate green or red colors by turning on only one LED at a time, yellow by turning both LEDs on by equal amounts, or any color between green and red by turning both LEDs on in the appropriate ratios.

MULTI-LED CIRCUITS

If several LEDs need to be driven from a single power source, this can be done by wiring all LEDs in series, as shown in *Figure 10*, provided that the supply voltage is significantly greater than the sum of the individual LED forward voltages. This circuit thus consumes a minimum total current, but is limited in the number of LEDs that it can drive. Any number of these basic circuits can, however, be wired in parallel, so that any number of LEDs can be driven from a single source, as shown in the six-LED circuit in *Figure 11*.

An alternative way of simultaneously powering several LEDs is to

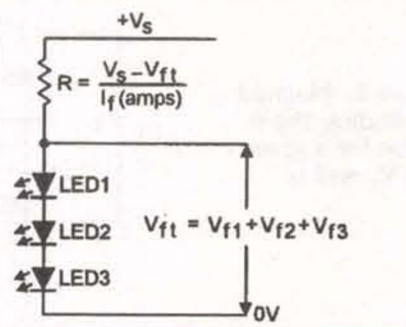


***Figure 10.* LEDs wired in series and driven via a single current-limiting resistor.**

simply wire a number of the *Figure 5* circuits in parallel, as shown in *Figure 12*. Note, however, that this circuit is very wasteful of supply current (which equals the sum of the individual LED currents).

Figure 13 shows a "what *not* to do" LED-driving circuit, in which all the LEDs are wired directly in parallel. Often, this circuit will not work correctly because inevitable differences in the forward characteristics of the LEDs cause one LED to hog most or all of the available current, leaving little or none for the remaining LEDs.

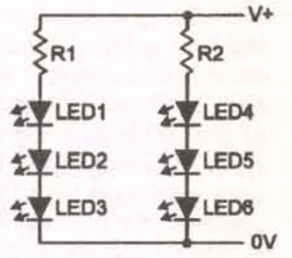


***Figure 11.* Any number of *Figure 10* circuits can be wired in parallel, to drive any number of LEDs.**

LED FLASHER CIRCUITS

SIMPLE DESIGNS

One of the simplest types of LED display circuit is the LED flasher in which a single LED repeatedly switches on and off, usually at a rate of one or two flashes per second. A two-LED flasher is a simple modification of this circuit, but is arranged so that one LED switches on when the other switches off, or vice versa.

Figure 14 shows the practical circuit of a transistor two-LED flasher, which can be converted to single-LED operation by simply replacing the unwanted LED with a short circuit. Here, Q1 and Q2 are wired as a simple 1Hz astable multivibrator, in which Q1 and LED1 turn on as Q2 and LED2 turn off, and vice versa, and in which the astable switching rates are controlled by the values of C1-R3 and C2-R4.

Figure 15 shows an IC version of the two-LED flasher, based on a 555 or 7555 timer IC that is wired in the astable mode, with its main time constants determined by the C1 and R4 values and giving a cycling rate of about 1Hz (one flash per second). The circuit action is such that output pin 3 of the IC alternately switches between the ground and the positive supply voltage levels, alternately pulling LED1 on via R1 or driving LED2 on via R2. The circuit can be converted to single-LED operation by omitting LED2 and R2.

Figure 16 shows a useful modification of the above circuit, in which the flashing rate is made variable via RV1, and two pairs of series-connected LEDs are connected in the form of a cross so that the visual display alternately switches between a horizontal bar (LED1 and LED2 ON) and a vertical bar (LED3 and LED4 ON), thus forming a visually interesting display. The cycling rate is variable from 0.3 to 3 flashes per second.

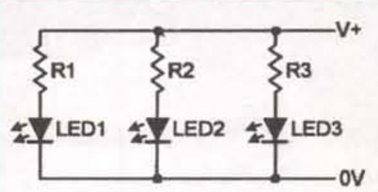


***Figure 12.* This circuit can drive any number of LEDs, but at the expense of high current.**

MICROPOWER LED FLASHERS

Simple LED flasher circuits of the types shown in *Figures 14* to *16* consume mean operating currents of several milliamps. Micropower LED flashers, on the other hand, consume mean operating currents that are measured in microamps (typically ranging from 2µA to 150µA), and are intended mainly for use in battery-powered 'emergency indicator,' 'battery state,' and 'burglar deterrent'

PRACTICAL LED INDICATOR AND FLASHER CIRCUITS

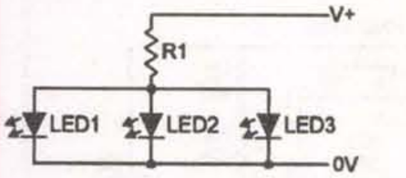


Figure 13. **This LED-driving circuit may not work; one LED may hog most of the current.**

applications.

In emergency indicator applications, micropower LED flashers can be used to indicate the positions of emergency exits, lanterns, torches, alarm buttons, or safety equipment, etc., under dark conditions (perhaps caused by a failure of a main lighting system). When used as battery state indicators, they are often fitted in smoke alarms and other low-current long-life units that are powered by

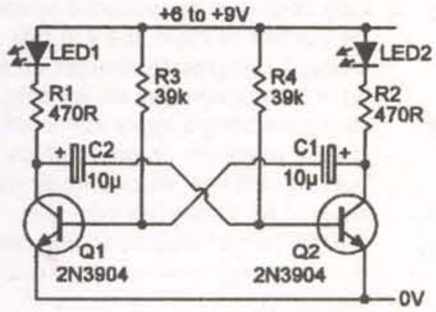


Figure 14. **Transistor two-LED flasher circuit operates at about 1Hz.**

4.5V to 12V batteries. When used as burglar deterrents, they are prominently fitted to real or dummy burglar alarm control or alarm/siren boxes or CCTV cameras, etc.

To understand the basic principles behind micropower LED flashers, you must first learn some basic facts concerning visual perception, as follows.

(1). The human eye/brain combination is sharply attracted by sudden changes in visual patterns or light levels; it is particularly sensitive to some types of flashing light. *Figure 17* shows the typical 'light flash' response of the human eye/brain combination when presented with a bright LED-generated pulse of light.

(2). Note from *Figure 17* that the flash must be present for at least 10mS to be seen (perceived) at full brilliance, and that — when the flash terminates — the 'persistence of vision' effect causes the perceived brilliance to decay fairly slowly, typically taking 20mS to fall to 50% of its maximum (pre-switch off) value. Consequently, the eye can only see flashing lights as *individual* flashes if they are separated by a period of at least 20mS; if they are separated by less than 20mS, they are seen (because of the 'persistence of vision' effect) as a continuous light.

(3). Also note from *Figure 17* that — if the flashes are separated by at least 20mS — the brain 'sees' the individual flashes at full brilliance if they have a duration of 10mS or greater, but sees them at diminishing brilliance at durations below 10mS (a 2mS flash appears at roughly 1/5th of true brilliance; the perceived brilliance falls off rapidly at durations below 1mS). The perceived *duration* of a 20mS flash (30mS) is only 50% greater than that of a 10mS flash (20mS).

(4). The human eye/brain combination is very sharply attracted by flashing lights that have repetition periods in the approximate range 0.5 to 5 seconds, but is less attracted by

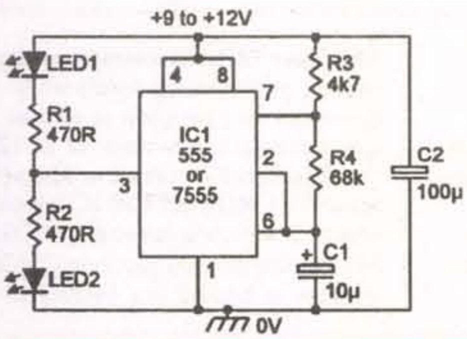


Figure 15. **IC two-LED flasher circuit operates at about 1Hz.**

flashing lights that have repetition periods above or below this range.

(5). Modern low-cost Super Bright LEDs, when generating a 10mS or longer light pulse, produce a brightness level that is adequately eye-catching for most practical purposes when pulsed by a 2mA current.

When the above sets of facts are put together, it transpires that the 'ideal' micropower LED flasher — when using a Super Bright LED — should produce a pulse with a

PRACTICAL LED INDICATOR AND FLASHER CIRCUITS

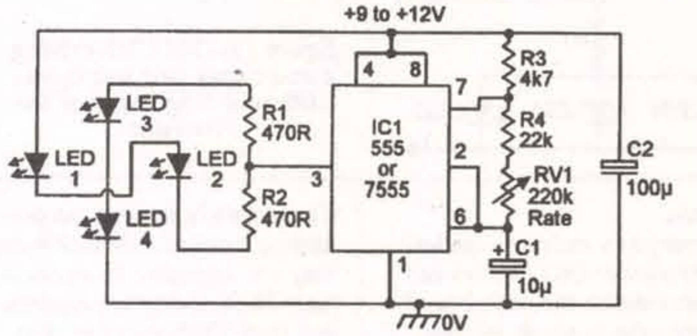


Figure 16. **The rate of this four-LED double-bar flasher is variable from 3 to 0.3 flashes per second.**

duration (d) of 10mS at a current (I) of 2mA, at a repetition period (p) of 2 seconds (= 2000mS). Note that, under these conditions, the *mean* current (I_{mean}) of the LED is given by

$$I_{mean} = I \times d/p$$

and is a mere 10µA in this particular example (at a 30 second repetition period, I_{mean} is a minute 0.67µA).

In practice, the *actual* mean current consumed by a micropower respectively.

The *Figure 18* circuit is designed around a CMOS 7555 'timer' IC that is used in the astable mode and typically consumes an unloaded operating current of 75µA at 6V. In this mode, C1 alternately charges up via R1-R2 and discharges via R2 only, thus generating a highly asymmetrical output waveform on pin 3, which pulls the LED on via current-limiting resistor R3 during the brief 'discharge' part of each operating cycle.

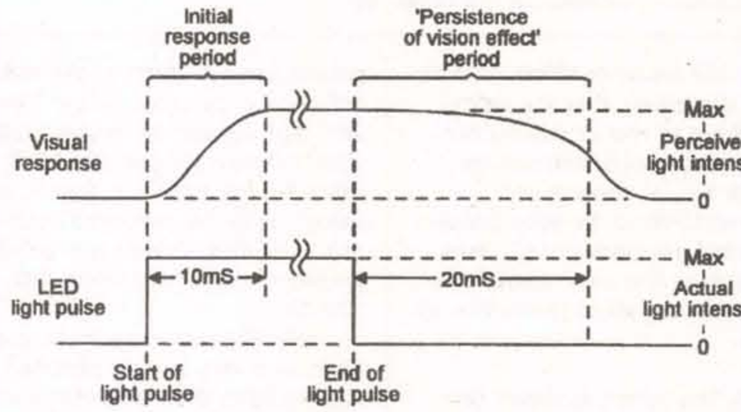


Figure 17. **Typical 'light flash' response of the human eye/brain combination.**

LED flasher circuit is equal to the sum of the LED and the driver currents, and is inevitably higher than the minimum figure indicated above. *Figures 18* and *19*, for example, show two alternative micropower LED flasher circuits that — when powered from 6V supplies — consume total currents of 86µA and 12µA, respectively.

The *Figure 18* table summarizes the circuit's performance details when optimized for operation at various spot voltages in the range 3V to 12V.

The *Figure 19* circuit is designed around a CMOS 4007UB IC, which contains two complementary MOSFET transistor pairs plus one CMOS inverter, all housed in a 14-pin DIL

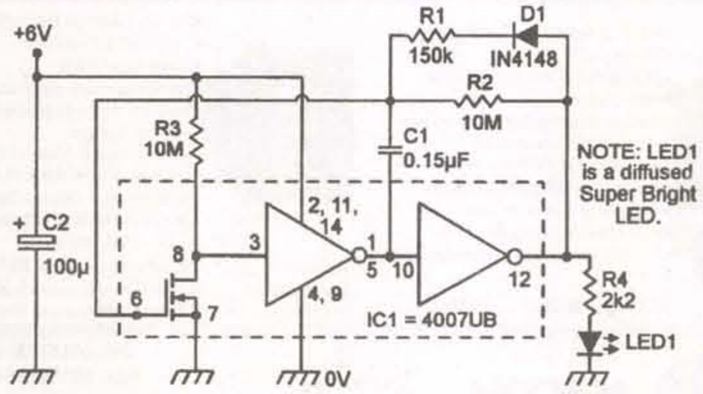


Figure 19. **This 4007UB-based micropower LED flasher circuit consumes a mean current of 12µA at 6V.**

V+	R3	Current drain Loaded	No Load
3V	1.5k	68µA	60µA
4.5V	1.5k	80µA	70µA
6V	2.2k	86µA	75µA
9V	3.3k	97µA	85µA
12V	4.7k	107µA	95µA

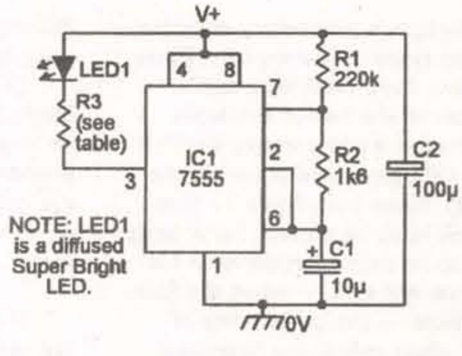


Figure 18. **Circuit and performance details of a 7555-based micropower LED flasher unit.**

package.

In this application, the IC is wired as a micropower ring-of-three asymmetrical astable multivibrator which — when powered from a 6V supply — drives the LED on for 10mS at two-second repetition intervals; the ON time is controlled by C1-R1, the OFF time by C1-R2, and the LED current (2mA nominal) is controlled by R4. The circuit consumes an unloaded operating current of 2µA, and a loaded current (when driving the LED with 2mA pulses) of 12µA.

Note that the *basic* circuit of *Figure 19* can be used at any supply voltages in the range 4.5V to 12V, but that the actual component values must be selected to suit the specific supply voltage used. Also note that — at supply voltages of 6V or greater — the circuit can drive two or more series-connected LEDs without increasing the total current consumption, provided that R4's value is altered to set the LED ON currents at 2mA.

The table in *Figure 20* shows the nominal life expectancies of various types of alkaline cell/battery when continuously driving various types of micropower LED flasher circuits. The data relates to the circuits in *Figure 18* (drawing 86µA at 6V), and *Figure 19* (drawing 12µA at 6V), and to the once-popular but now obsolete LM3909 'LED flasher' IC (withdrawn from production by National Semiconductor), which draws a minimum operating current of 320µA.

Note in *Figure 20* that the 'predicted cell/battery life' figures relate to cells/batteries that have initial (unused) life expectancies of five years, i.e., in which their charges leak away at a steady rate of 1.67% per month. The total in-use monthly capacity drain equals the sum of the leakage and the loading drain figures, and forms the basis of the life prediction figures shown in the table.

LOW-VOLTAGE MICROPOWER LED FLASHERS

The basic micropower LED flasher circuit in *Figure 19* can — if its component values are suitably selected — be reliably used at an absolute minimum supply voltage of 4.5V. If you have an application where you need to drive this basic flasher circuit from a 3V battery, you can do so by using the 3V battery to directly drive a super-efficient voltage-doubler circuit based on the popular ICL7660 IC, and use the 6V output of the doubler (connected directly across C2 in *Figure 19*) to power the 6V version of the *Figure 19* circuit which, in this case, will consume a mean current of 24µA from the 3V battery.

Alternatively, if you need to drive the basic flasher circuit from a 1.5V cell, you can do so by using the cell to drive a cascaded pair of ICL7660 voltage-doubler circuits, and use their 6V output (connected directly across C2 in *Figure 19*) to power the 6V version of the *Figure 19* circuit which, in this case, will consume a mean current of 48µA from the 1.5V cell. **NV**

Alkaline cell/battery type	Capacity (per cell or battery)	12µA Load drain	life	86µA Load drain	life	320µA Load drain	life
		monthly capacity drain & predicted cell/battery life					
AAA (1.5V)	1Ah	0.88%	3.3 Yrs	6.28%	1.0 Yrs	23.4%	0.3 Yrs.
AA (1.5V)	2Ah	0.44%	4.0 Yrs	3.14%	1.7 Yrs	11.7%	0.6 Yrs
C (1.5V)	6.5Ah	0.135%	4.6 Yrs	0.97%	3.2 Yrs	3.6%	1.6 Yrs
D (1.5V)	13Ah	0.07%	4.8 Yrs	0.48%	3.9 Yrs	1.8%	2.4 Yrs
PP3 (9V)	0.55Ah	1.59%	2.6 Yrs	11.4%	0.6 Yrs	42.5%	0.2 Yrs

***Figure 20.* Table showing the life expectancies of various types of alkaline cell/battery when driving micropower LED flasher circuits.**

Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

QUESTIONS

I would like to build a "bug zapper" that's easy to build using few parts. I want to use them mostly on earwigs and spiders. An easy circuit diagram is all I need.

3001 **Sumeth Kongsuwan**
Belvidere, IL

I need a circuit that when 150 volts AC is applied, the output would be +5 volts DC, and when the voltage goes down to 100 volts AC, the output would be 0 volts DC, and at 125 volts AC, it would be 2.5 volts DC.

What I have is a chart recorder that the input is from 0 to +5 volts DC and I would like to use it as an AC voltage recorder.

3002 **Thomas Trode**
Custer, SD

How can I use the serial and parallel port to turn any load on? Could someone help or tell me where can I find information?

3003 **Letty Guerrero**
via Internet

Can someone give me a simple circuit design that will track the sun for a solar panel and tracking sound?

3004 **Tim Kirsch**
Chandler, AZ

Can anyone walk me through the required steps to change my keyboard — Windows 98 — Compaq model 5304.

It has some upper keys called Internet. I have changed from Internet Explorer that it came with to Netscape. I have the Netscape icon on the desktop and that works okay, but I would like to make these keys go to Netscape and not still to Internet Explorer. Can someone help a newcomer to computers?

3005 **Roger W. Hamel**
Cedarville, MI

Check all of your computer directories/folders. You will probably find some hidden *.gid files. What are these files?

3006 **Anonymous**
via Internet

In the February issue of *Nuts and Volts*, there was an answer to a question about the Intel Play QX3. I'm not knowledgeable about video cameras and monitors. The answer to question #1008 by Gerald Roylance piqued my interest.

I have a pretty good dissecting microscope and I would like to be able to project images of material on the microscope stage onto a TV B/W screen. I don't necessarily want to record the images. Where does one get a "relay lens system" and a C-mount camera?

Can one use a B/W TV set to view what the camera sees? If not, what additional material is needed? Can I do all this and not double the cost of my $700.00 microscope?

3007 **Donald Siehr**
via Internet

I hope someone can help me locate an RCA television part that is no longer available from RCA distributors. The Model number is PJR 500/600 Projection Television.

The part I need is symbol #M701 and RCA part #158796 module, a thick film device edge mounted with 19-pins, used for sync sep., horiz., vert. oscil., and drivers. Or, if someone would have a deflection board (this contains the module) RCA part #155821. I have had no luck at the local level.

3008 **Donald E. Wood**
via Internet

I am a ham operator and have a receiver and transmitter.

I have a 600 ohm 1MW audio output. This output is too low to drive my Collins phone patch. I need at least 1 watt or 1.5 watts to drive the patch. The input to the patch requires 500 ohm.

I would like also to control the level out.

3009 **Leland Callender**
Theodore, AL

ANSWERS

ANSWER TO #20016 - FEB. 2000

Is there a simple circuit that someone has designed to enable three keyboards to be physically tied to a PC?

If you are using Windows, the simple solution is to just connect two USB keyboards to the computer. No other circuitry is required.

A friend connected one USB keyboard to his computer that had an ordinary keyboard and found that both keyboards worked, and I expect it will work with two USB keyboards, too.

Each keyboard directed its input to the active window. Of course, if two people are typing at the same time, their input is shuffled together.

An interesting behavior was pressing CAPS LOCK on one keyboard set CAPS LOCK on all keyboards.

Gerald Roylance
Mountain View, CA

ANSWER TO #129914 - DEC. 1999

I have an EEPROM reader and writer card that plugs into an eight-bit ISA slot on the motherboard of my desktop.

Does anyone know a way to hook this ISA card to a laptop so that I can program the EEPROM in the field?

Check your computer for a docking port. If it has one, try to find a used docking station, which some had room to hold full-size ISA cards.

If this does not work out, my next suggestion would be to seach for local junk sales, auctions, and hamfests for a 1980s "luggable" portable, which some had room for half-size ISA cards.

Compaq's first portable would be a really good option, if you could find one.

The other option is to look for a parallel port programmer such as the Dataman-48 from **www.dataman.com**. The Conitec Galep-III **www.conitec.com** or the pocket programmer from: **Intronics, Inc.**, Box 13723, 612 Newton St., Edwardsville, KS 66113; **913-422-2094** voice, **913-441-1623** fax.

A company that I have bought equipment from is **www.jdr.com**. They also sell different types of programmers.

Dan Hockey
via Internet

ANSWER TO #12998 - DEC. 1999

A student wants to build a Tesla coil that operates from 12V (two six-volt lantern batteries).

We know we can use a 555-timer circuit to generate the pulses we need, but also need an efficient way to boost the voltage out of the pulser circuit to 25V-50KV.

The article on Tesla coils in the Sept. '99 issue was excellent, and should provide a good starting point.

The 12-volt operation could be done using what used to be called a model "T" coil. Basically, it was an ignition coil from a Model "T" Ford coil. They are probably still available in mail order like JC Whitney.

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

The Model "T" coil output is used to produce the high voltage for the spark gap that excites the primary coil for the Tesla coil in the Sept. issue.

This coil had an integral buzzer built in that provided the interrupted six volts that ran the primary of the ignition coil. This buzzer was later replaced with the ignition points in the distributor of more recent internal combustion engines and, most recently, electronic and computer-controlled ignition.

Another alternative is to obtain a 1960-1980 ignition coil and, with a 555 or even a doorbell buzzer, provide the interrupted DC that provides the primary excitation and route the secondary to a spark gap, and into the primary input coil of the Tesla coil.

If the latter method is used, be sure to damp the primary of the ignition coil with a capacitor that was typically mounted in the auto distributor. This allows the counter EMF produced by the collapsing magnetic field in the ignition coil to be bypassed across the points and not burn the points. It also provides a hotter spark at the output.

Obviously, there is extremely high voltage present, so use care in handling the secondary of the ignition coil.

Unlike the output of the Tesla that is high frequency and travels over or at the surface of the skin, and will not cause the shock sensation, the secondary of the ignition coil is fairly low frequency, and has a pretty good amount of current available, so a nasty shock can be experienced.

The primary — even though powered with 6 or 12 volts — can also provide a good shock when operating due to the counter EMF provided by the collapsing magnetic field in the coil.

Ed Pruitt
Keller, TX

ANSWER TO #12995 - DEC. 1999

I have a Webster-Chicago wire recorder transport mechanism. Unfortunately, without electronics.

Where can I find either the electronics package or complete plans to build it? I would also need the wire which the recorder uses.

The recorder requires a very special oscillator coil which was originally supplied as an individual part with the deck. The coil along with a 6V6 and 6J5 tubes provide approximately 1 ampere at 5 volts and 40 KHz to the head for bias and erase.

The circuit requires 200 volts DC and 6.3 volts AC for the tubes. Any solid-state circuit capable of delivering the frequency, voltage, and current will work.

As to the wire, it is .004" diameter stainless steel and comes on reels made to fit the unwind spindle. I have no idea where this wire might be found today.

If Mark will send $3.00 for copying and postage to: Bob Radmore, P.O. Box 312, Olcott, NY 14126, I will send him the eight sheets of information about the wire recorder and would be more than happy to answer his questions.

Bob Radmore
via Internet

ANSWER TO #2008 - FEB. 2000

I need a circuit to reproduce the tone of a chime tube. It needs to be a realistic sound, not something like a cheap doorbell, more like Big Ben.

I am assuming you need to create a small, battery powered portable device to generate your chime sound. If size and power are not constraints, then using a PC-compatible computer with sound card would be the easiest solution.

To build a device that generates a single, fixed sound, the easiest way is to store a sampled audio waveform in an EPROM or flash memory chip. The EPROM data outputs drive a digital-to-analog converter (DAC), which drives an amplifier and speaker.

To generate a one-second duration sound at a 16 KHz sample rate (giving you a little below 8 KHz frequency response), would take 16K bytes (assuming eight-bit samples). 16K bytes is 128K bits, so you would need a 128K memory chip (for example, 27128). These devices have 14 address lines (2^14 = 16K). To create a sound, you will need a 14-bit counter and an oscillator that will run at 16 KHz.

If you use a DAC with an internal data holding register, then you can use a ripple counter. Clock the DAC with the same clock that clocks the counter, and the glitches in the counter output won't be seen at the DAC output. To trigger the sound, you can use a D flip-flop with a negative edge clock and a preset. The trigger presets the flip-flop, which enables the counter to count. The D input of the FF is tied low. The highest order bit of the counter (MSB) is connected to the FFs clock.

When the counter reaches the terminal count and returns to zero, the FF output is clocked to the low state, thus disabling the counter (and the sound) until re-triggered. If you are able, it is easiest to implement the logic in a PAL or CPLD.

Tim Godfrey
via Internet

ANSWERS TO #20011 - FEB. 2000

I have lost the power supply to my practical peripherals PM144MT II modem and need the voltage and current to get a replacement.

#1 The AC wall power supply requirements are: 9V at 1000 mA. I use this same modem, and am reading the data directly off the stock unit.

Barry Tuttleman
Carson City, NV

#2 The practical peripherals external fax modem PM144MT II, model PM 14400 FX MT uses the following power supply manufactured by Electro-Mech Corp.

Class 2 Transformer; Input: 120 VAC, 60 Hz, 15W; Output: 10 VAC, 10 VA.

The manual that's included with this fax modem, lists the same specs except the output at 9V AC and 850 mA.

Arthur Hazboun
Harbor City, CA

ANSWER TO #2004 - FEB. 2000

I have a Zenith Data System laptop computer model ZFL 181-92 and cannot find any information about it. I need to know the processor speed and size of hard drive.

The specifications for your Zenith Data System 181-92 are as follows:

80C88 CPU 4 MHz; 640K RAM; CGA video; LCD display (res.

ANSWERS TO #20012 - FEB. 2000

I have a Velleman PAL to RGB converter. It doesn't seem compatible with my USA video signal.

I can't do the first step of calibration, picture is B/W and RGB controls affect brightness of picture.

What are PAL, composite, and NTSC video and how can I get this box working?

#1 The NTSC system uses 525 horizontal lines and 30 frames-per-second (60 fields/sec., interlaced). The PAL system uses 625 horizontal lines and 25 frames-per-second (50 fields/sec., interlaced).

The scanning sequence is left to right and top to bottom in both, but the NTSC signal is high voltage equals white, low voltage equals black while the PAL signal is the opposite. High voltage equals black, low voltage equals white. In the PAL system "snow" is black, I guess you would call it "mud."

The other problem you face is that the RGB processing is different. I am quoting here from *"Reference Data for Radio Engineers"* by Howard Sams & Co., a subsidiary of ITT. "In the NTSC system, the color difference signals I and Q amplitude-modulate subcarriers that are displaced by pi-2, giving a suppressed-carrier output. A burst of the subcarrier frequency is transmitted during the horizontal back porch to synchronize the color demodulator.

In the PAL system, the phase of the subcarrier is changed from line to line, which requires the transmission of a line switching signal, as well as a color burst."

I don't know if the color subcarrier frequency is the same in the NTSC and PAL system, but probably not because the NTSC horizontal frequency is required to be 2/455 times the color subcarrier.

Russell Kincaid
Milford, NH

#2 Your box is looking for a PAL video signal, and you are feeding it NTSC. The signals have different components at different frequencies. That is the problem.

Video comes in several formats, the most popular are NTSC, PAL, and SECAM.

NTSC (National Television Standards Committee) format is used in the US and all countries where AC's main power is 60 Hz. PAL (Phase Alternating Line) is used in countries where power is 50 Hz. SECAM is used only in France, as far as I am aware.

Frequencies, timing, and other parameters are different between PAL and NTSC. Also, the audio subcarrier is 4.5 MHz up with NTSC and 5.5 MHz up with PAL. PAL has a bit more resolution.

Within the PAL family, there are additional country-specific formats. PAL-M, PAL-N, PAL-B, and PAL-C are typical of these. For your purposes, you will not need to be concerned with the differences within the PAL family.

If you try to view a PAL signal on an NTSC monitor, you will see a large black bar at the bottom of the screen. You also will have poor sync, and likely no color since the frequencies are different.

If you have a lot of time and like to play, it might be possible to change a crystal in your Velleman box to change the frequency from PAL to NTSC. You also would have to change some capacitor values in filtering stages.

I don't know how you would determine the changes necessary unless Velleman happened to make two identical boxes, one for PAL and one for NTSC. Then you could get schematics for both and see the differences. It is not worth the effort. You would be better off to sell the thing and buy a proper unit.

Another alternative which will cost about $50.00 is to purchase an NTSC-to-PAL converter. Clearline Concepts makes a small unit available from video equipment distributors. This box takes the NTSC video, demodulates it, and re-encodes it to PAL standards. The box converts video only, as audio is the same with either format.

Squirt your video through the NTSC-to-PAL converter, then into your Velleman box and, theoretically, you should be okay. You may be able to purchase the NTSC-to-PAL converter with return privileges, if it doesn't work for you.

In answer to your question, composite video is a single line with the video and sync combined. It is what you normally will deal with. For special effects, switching, or high-performance video systems, the video and sync may be processed separately. You probably will not run into this at the consumer level. Hope you get it working.

Steve Uhrig
Street, MD

ANSWERS TO #2007 - FEB. 2000

I want to be able to digitally create and output a musical tone or note directly to one or more speakers.

I am able to generate a frequency using an output port of a micro controller, but it sounds like a buzz rather than a tone.

#1 There are different solutions for tone generation depending on whether you are limited to driving a single bit or not. Since you are looking for a musical tone or note, let me recommend the best approach first.

That is to connect a digital-to-analog converter (DAC) to your microcontroller. The DAC provides an analog output that drives your speaker through an amplifier. Depending on the quality you need, you can use 8, 12, or 16-bit DACs.

You must provide the DAC with sample updates on a continuous basis from your software. Typically, a sampled audio waveform is stored in memory, and the microcontroller reads values from memory and writes them to the DAC. The sample update rate must be at least two times the maximum frequency you want to reproduce.

If you are limited to using a single bit driving a speaker in a binary fashion, then your only option for generating an audio signal (other than a "buzzy" pulse waveform) is to use Pulse Width Modulation (PWM). Your software routine still reads a table of samples from memory, but for each sample, the output pin is driven high and low for varying amounts of time.

The ratio of time between high and low is proportional to the value of the sample. The actual rate the pin is changing state will be well above the range of hearing. A low-pass filter between the pin and the speaker causes the speaker to be driven by the average voltage of the pin, thus providing an analog signal that is able to represent an arbitrary waveform.

In addition to updating at the basic sample rate mentioned above, each sample has to be subdivided into high and low portions that are averaged by the filter. To create a range of different voltages, each sample interval must be subdivided into a number of time slots.

The software loop must update the pin at a rate that is equal to the sample rate times the number of time slots per sample. That can result in a very short time (less than 1uS) for the software loop to execute if you want reasonable quality.

There is a good example of the PWM technique with some background theory at http://www.mit.edu/people/bunnie/proj/shrisc/shrisc.html.

Tim Godfrey
via Internet

#2 If you are trying to make musical tones, you should look at some books about MIDI and its music synthesizer technology. Most Windows-based sound cards include a MIDI synthesizer.

With your output port, you are probably generating a squarewave. It sounds like a buzz because there are many harmonics. To get a pure tone, the easiest solution is to connect a DAC to the output port and send sine values to the DAC every 20 microseconds.

You can also add in other tones or harmonics to the value sent to the DAC. A good implementation includes an anti-aliasing 20 KHz low-pass filter after the DAC.

You don't need the DAC if you pulse-width modulate a one-bit output port, but that requires about 100nS resolution for mediocre results. You could use a delta modulator, but the details are getting involved.

Both techniques are synthesizing a DAC with a one-bit output. DACs are simple and cheap, so just use a DAC.

The processes are involved and require an understanding of mixing in the frequency domain, but the bottom line is you don't need three speakers, one will do.

Gerald Roylance
Mountain View, CA

640x200 pixels); serial/parallel port; and dual 3.5" 720K disk drives.

If it has a modem, it is probably 1200 or 2400 baud and it probably doesn't have a hard drive. The model number you listed didn't have one.

You can open the unit and cross-reference the drive model number from the manufacturer's website.

Paul Stafford
Flower Mound, TX

ANSWER TO #2003 - FEB. 2000

I have an old Allied SX-190 shortwave radio which I need a schematic and possibly an operation manual for.

Radio Era Archives has the SX-190 schematic that you want. The catalog number is 20073 and the cost is $25.20. Their address is **2043 Empire Central, Dallas, TX 75235**. Or find them on the world wide web.

Russell Kincaid
Milford, NH

ANSWER TO #2006 - FEB. 2000

I have a radar detector that is X, K, Ka, and laser. It also has "VG2" alert, occasionally it will alert, and the display will read out "VG@ Alert Radar may be in use."

Is the message I see a canned message that is triggered by sending a simple message number code, or is the complete message sent? Basically, what are the details of the VG2 alert messages and where do they come from?

You were correct to assume the VG2 alert is a canned message. The VG2 is the police-operated radar detector, detector unit. It also has a local oscillator that can be detected by your radar detector.

Whenever your detector receives this frequency, it will respond with a canned VG2 alert message to warn you to take action and turn off your detector in states where radar detectors are illegal.

Because there are so many radar sources out there — door openers, traffic control, aircraft, and even other radar detectors — your detector is often fooled into responding with a VG2 alert. If radar detectors are legal where you live, just disregard the alert.

Ken Olsen
via Internet

ANSWER TO #2002 - FEB. 2000

I have a Techny MC200 microprocessor board with an RS232 COM port connection without means to talk to a PC.

Does anyone know of software or a flexible/configurable driver to get data from this microprocessor into a PC?

Since your MC200 has an RS232, I would connect it via a null-modem serial cable to your PC and use a commercial terminal emulator like Procomm or HyperTerminal to talk to it. My guess is that it talks at 9600 baud, 8-bits, no parity.

Alan Sheets
Loveland, CO

ANSWER TO #20020 - FEB. 2000

My father recently acquired a Panasonic color video camera, (without recorder) model WV-3160 at an auction. It has a din-type connector with somewhere between five and seven pins.

Any information on the pinout of the connector or a source for a recorder would be appreciated.

Camcorders are a fairly recent product. Before camcorders (CAMera and reCORDER), separate cameras and video recorders were used.

Your dad's Panasonic WV-3160 is a high-quality consumer grade camera only, intended to be used with a separate recorder. The camera dates to approx 1981, and uses a Newvicon image tube. It is a fairly high-resolution, fairly low-light color camera even by today's standards.

The camera is powered by 12-VDC usually provided by the recorder. Your camera has the standard 10-pin connector common to portable video equipment of this era.

Recorders for these cameras largely are extinct. Any of the Panasonic, Elmo, RCA, or similar

ANSWERS TO #20013 - FEB. 2000

I have a robot that is controlled with the serial port on my computer. I would like to convert it to USB. Where can I find information on USB and can I access it using QuicBasic?

#1 The simple solution is to buy a USB to serial port converter, Belkin and others sell these devices. That will save your COM ports for other uses.

The programming interface in QuickBasic should look just like a COM port. You would open the device as a file. There might be a problem if QuickBasic tries to talk with the COM port using BIOS calls — the USB serial port driver probably doesn't try to emulate the BIOS interface. I don't have a USB serial port, but my USB parallel port does not show up on the BIOS equipment list.

Rolling your own USB interface is a much more difficult affair. You can find the USB specification at **www.usb.org**. Not only do you have to make the hardware follow that spec, but you must also make a Windows device driver — an enormous exercise.

I would point you to Cypress Semiconductor and their low-speed USB starter kit ($100.00 and based on an M8 microprocessor) because you can hack it to make a bit flipper, but their Windows driver (without source code) is seriously flawed and will hang your computer. Their high-speed EZ-USB kit ($500.00 and based on an 8051) is probably better, but I haven't tried one.

Building drivers is arcane and there are many roadblocks. I don't know if it is still true, but a year ago, you had to use Microsofts old (V5) C compiler instead of their newer (V6) compiler to build a device driver.

Some Windows driver details can be found at **www.msdn.com**. Many companies, such as Wind River, sell device driver development kits, but they are not cheap. My advice is to stick with the serial port.

Gerald Roylance
Mountain View, CA

#2 I found a really neat website that has just what you describe. It is a company called **ActiveWire** (see ad on page 78) and their website is **www.activewireinc.com**

Paul Stafford
Flower Mound,TX

#3 There is a web page titled "Using RS232 Devices with USB" at **www.ontrak.net/usb.htm**. They list a product called the "Peracom US1000A USB to Serial Converter."

It comes with a driver that makes it look like a regular serial port when installed in your computer. It is available from USBSTUFF **www.usbstuff.com** for $64.95 US. (Also see **www.allusb.com/products/P10069.html**.)

Whatever QuickBasic code you are using now could access the Peracom serial port over USB, presumably without any changes. I am assuming you are using Windows 95 OSR2.1 or Windows 98. It is difficult, if not impossible, to use USB under DOS or earlier versions of Windows.

Tim Godfrey
via Internet

TECH FORUM

portable video recorders with a 10-pin connector should work with your camera as the connections and signals were standard, with the exception of Sony. A typical video recorder is the Pánasonic AG2400 which were very popular in their day, and were about the size of a telephone directory.

Since your camera outputs standard video, you can use it with any video device, including your home VCR. All you have to do is match the connections.

Although you could cut off the 10- pin male connector at the end of the cable coming from your camera, it is rather a shame as the connectors are convenient and high quality. RadioShack used to sell chassis-mount female 10-pin connectors; and **PC Electronics, www.hamtv.com, 626- 447-4565**, in California, probably still carries them. Get a connector and wire it as described below.

Merely make up a cable to connect to your VCR or whatever, using the following connections:

References are from looking at your male 10-pin connector from the solder side. Put the gap pointing up. First pin clockwise is pin 1. Eight pins around the circle, pin 8 at approx. upper left. Two pins in the middle.

In center, pin 9 is at top, pin 10 below it.

The signals are:

1 - Video high
2 - Ground
3 - Data (ignore, model specific)
4 - Clock and tally (ignore, model specific)
5 - Standby (ignore)
6 - Recorder pause (ignore)
7 - Audio high
8 - Ground
9 - Ground
10 - +12 VDC

So, take your video out of 1 and 2. Audio out 7 and 8. 12 VDC in on 10 and 9.

There also were external power supplies and breakout boxes sold for use with your type of camera. These were about the size of a carton of cigarettes and had a 10-pin connector mounted on one end. The box plugged into the wall for power, operated the camera, and gave you RCA jacks out for video and audio. You still see them at hamfests for about $10.00.

You do not need to get Panasonic-brand equipment. Anything with the 10-pin connector will work.

You have a nice camera. Even though it is older and larger, it is a rugged device capable of almost any portable video requirement.

Steve Uhrig
Street, MD

ANSWERS TO #2009 - FEB. 2000

I am seeking a C-language compiler for the PIC family of microcontrollers.

#1 A very low-cost $100.00 C-language compiler for the PIC processor family is available from **Custom Computer Services, 414-781-2794, www.ccsinfo.com**. A better, but more expensive PIC compiler, is available from **Byte Craft Limited, 519-888-6911 www.bytecraft.com.** I have used the CCS product with mixed results. Be sure to order their support service (another $100.00 a year) if you expect to keep up with compiler bugs or PIC processor changes.

T. Black
Folsom, CA

#2 There are a number of references to C compilers for the Microchip PIC family on the Internet. There is a Microchip Net Resources site at **www.geocities.com/Silicon Valley/Way/5807/dat.html**. It contains this list of C compilers:

Small C compiler V C3.0R1.1 with sources by **Chris Lewis** (free) (104K) **www.geocities.com/Silicon Valley/Way/5807/pic_cc.zip**

ANSI C compiler for Microchip PIC by **HI-TECH software** (both free and commercial) **www.htsoft.com**

Development Assistant for hi-tech C compiler, developed by **RistanCASE www.ristancase.ch/da-c/index.htm**

PIC_C compiler v1.0 by **Collin Brendemuehl/DPC** (shareware) (15K) **www.geocities.com/Silicon valley/Way/5807/pic_c.zip**

MPC Code Development System by **Byte Craft Limited www.bytecraft.com/impc.html**

PIC16CXX C compiler by **Custom Computer Service www.ccsinfo.com/picc.html**

CC5X C compiler for all PIC16C5X/16CXX by **B. Knudsen Data www.geocities.com/Silicon Valley/Way/5807/cdemo20a.zip**

Pico-C compiler, written by **Hannu Jokinen personal.eunet.fi/pp/jokinen/**

Tim Godfrey
via Internet

#3 C language compilers for Microchip PIC microcontrollers are available from:

CCS, P.O. Box 2542, Brookfield, WI 53008, **414-781-2794** ext. 30. They have several versions available, both 12 and 14-bit. Their DOS-based compiler for the 12-bit chips is $99.00. Check their web site at: **www.ccsinfo.com/picc.html**

For 14-bit chips there is a $59.00 C compiler available from: **Grich RC Inc.**, 120 Cedar Grove Ln., #340, Somerset, NJ 08873, **732-873-1519** Check their web site at: **www.grichrc.com**

Parallax sells the Byte Craft compilers. They are expensive, so they must be good.

Another source for a C compiler in the same price range is **www.htsoft.com**. Probably you get what you pay for, but I couldn't tell you, being an assembler-type myself.

Jack Dennon
Warrenton, OR

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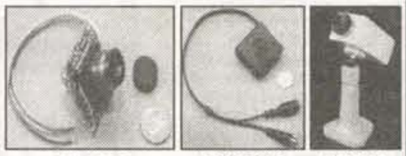

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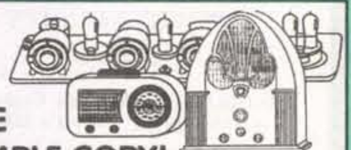

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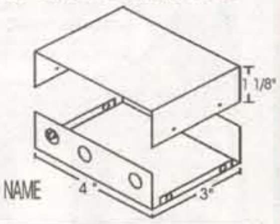

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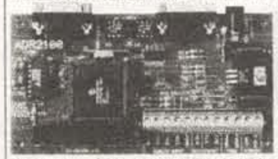

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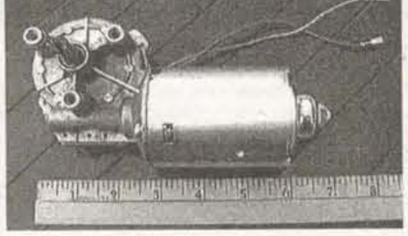

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Continued from page 60

Events CALENDAR

Continued from page 37

NJ - WEST ORANGE - Hamfest. High School, 600 Pleasant Valley Way. 8:30am-1pm. IRAC, Jim Howe N2TDI, 973-402-6066

TX - BRENHAM - Hamfest. Brenham ARC, Dan Lakenmacher N5UNU, 409-836-8739. E-Mail: lindan@phoenix.net

APRIL 2

CT - SOUTHINGTON - Hamfest. High School. 9am-1pm. Southington ARC, Chet Bacon KA1ILH, 860-628-9346. E-Mail: chet@chetbacon.com Web: http://www.chetbacon.com/sara.html

NC - KINSTON - Hamfest. Down East Hamfest Assn., Doug Burt W4OFO, 252-524-5724

APRIL 7-8

WI - MILWAUKEE - Hamfest. Amateur Electronic Supply, Ray Grenier K9KHW, 414-358-4088. E-Mail: rayk9khw@aol.com Web: http://www.aes/jam.com

APRIL 8

AR - FORT SMITH - Hamfest. Columbus Hall, 10201 Columbus Acres Rd. VE Testing. Talk-in: 146.940. Fort Smith Area ARC, Kelsey Mikel KK5KU, 501-651-7003. E-Mail: kk5ku@amsat.org Web: http://www.qsl.net/fsaarc

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

MN - ROCHESTER - Hamfest. Graham Arena E., Olmsted County Fairgrounds. VEC Testing. Rochester ARC, John Scott N0HZN, 507-285-6522. E-Mail: n0hzn@aol.com Web: http://members.aol.com/rarchams

NH - TWIN MOUNTAIN - Hamfest. Town Hall. 8am-2pm. VE Exams. Talk-in: 147.345 (114.8 Hz). North County ARC and LARK, Richard Force WB1ASL, 603-788-4428. E-Mail: bhabooks@together.net Web: http://www.qsl.net/k1ncr

OK - LAWTON - Hamfest. Lawton Ft. Sill ARC, Bob Morford KA5YED, 580-353-8074 or 580-355-6120

TN - CLINTON - Hamfest. Old Armory. 9am-4pm. Talk-in: 146.880 or 146.970. Oak Ridge ARC, David Bower K4PZT, 865-690-8360. E-Mail: d.bower@ieee.org Web: http://www.kormet.org/orarc

WA - SPOKANE - Hamfest. Lilac City ARC, Warren Kelsey KJ7BB, 509-534-8443

APRIL 8-9

FL - SARASOTA - Sarasota Municipal Auditorium, 801 N. Tamiami Trl. Frank Cox Productions, 941-954-0202

APRIL 9

NC - RALEIGH - State Convention. Jim Graham Bldg., NCS Fairgrounds. 8am-4pm. Raleigh ARC, Chuck Littlewood K4HF, 919-992-5851. E-Mail: k4hf@arrl.net Web: http://www.rars.org

NJ - HAMILTON TWP. - Hamfest. Tall Cedars of Lebanon picnic grove, Sawmill Rd. Talk-in: 146.67-. 609-882-2240. Web: http://www.slac.com/w2zq

PA - MONROEVILLE - Hamfest. Palace Inn, Mosside Blvd. 8:30am-3pm. Talk-in: 146.73, 147.12 repeaters and 146.52. Two Rivers ARC, Michael Kowalcheck KV3L, 412-751-9657. E-Mail: w3oc@nb.net Web: http://www.qsl.net/w3oc

WI - STOUGHTON - Hamfest. Madison Area Repeater Assn., Paul Toussaint N9VWH, 608-245-8890. E-Mail: n9vwh@arrl.net

APRIL 14-15

GA - ATLANTA - Southeastern VHF Conference. Dick Hanson K5AND, 770-844-7002. E-Mail: k5and@ga.prestigue.net Web: http://www.svhfs.org

APRIL 14-15-16

CA - VISALIA - International DX Convention. Holiday Inn. Southern CA DX Club, Cathy Gardenias KF6LFB, 909-862-0720. E-Mail: wu6d@dreamsoft.com Web: http://www.scdxc.org

APRIL 15

AL - ALBERTVILLE - Hamfest. Marshall County ARC, Buddy Smith KC4URL, 256-593-2516. E-Mail: kc4url@hiwaay.net

FL - MIAMI - Hamfest. Physics Parking Lot, University of Miami Campus. Talk-in: 146.865

Events CALENDAR

(-6). Flamingo/University of Miami ARC, Walt W4DWN, 305-895-0398

MN - BLAINE - Midwinter Madness. National Sports Center, 1700 105th Ave., N.E. 7:30am-2:30pm. VE Testing. Robbinsdale ARC, Harriet Johanson KB0UPG, 612-537-1722.
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NC - MORGANTON - Hamfest. Burke County Fairgrounds. 8am-4pm. Tom Taylor KC4QPR, 828-433-6205. E-Mail: kc4qpr@vistatech.net
Web: http://www.wp.cc.nc.us/~cvhamfest/

VA - CHESAPEAKE - Hamfest. Civitan Acres, 2210 Cedar Rd. 8am-12pm. Talk-in: 146.610 (-600). Chesapeake AR Service, Walton Hood K4WYS, 757-487-0357. E-Mail: wrhood@exis.net
Web: http://www.qsl.net/cars

APRIL 16

MA - CAMBRIDGE - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

MI - GROSSE POINTE - Hamfest. Grosse Pointe North High School, 707 Vernier Rd. 8am-2pm. Talk-in: 146.74-. South Eastern MI ARA, Jerry Rosner N8FGK, 313-331-3336.
E-Mail: n8fgk@amsat.org
Web: http://members.home.net/semara

MN - SHAKOPEE - Hamfest. Canterbury Park. 12-5pm. VE Testing. Talk-in: 147.165+. SMARTS, POB 144, Chaska, MN 55318

APRIL 21-22

AR - LITTLE ROCK - Little Rock Hamfest. The Little Rock Expo Center, Exit 126 on I-30. Fri: 4-9pm, Sat: 8am-4pm. Jim Blackmon K5VZ, 870-246-7833 (h) or 870-246-6734 (w). Fax: 870-246-6736. E-Mail: lrhamfest@usa.net
Web: http://www.aristotle.net/~ares/hamfest/

APRIL 22

ID - IDAHO FALLS - Hamfest. Idaho Falls Elks Lodge, 640 East Elva. Talk-in: 443.00+, 147.15+. Eastern ID UHF Society, Jay Greenberg WA4VRV, 208-524-1388 or 208-526-7033.
E-Mail: wa4vrv@srv.net
Web: http://www.srv.net/~wa4vrv/hamfest.htm

NH - NASHUA - Hamfest. Res Ctr Church. NE Antique RC 617-923-2665

APRIL 29

AL - MOULTON - Hamfest. H. A. Alexander Park, Court Street. 9am-4pm. VEC Testing. Talk-in: 53.17, 146.96 and 442.425. Bankhead ARC, Rex Free KN4CI, 256-905-0822.
Web: http://www.homestead.com/n4idx

CA - SONOMA - Hamfest. Sonoma Valley Veteran's Memorial Bldg., 126 1st St. W. 8am-12pm. VE Testing. Talk-in: 145.35, -600, PL 88.5. Valley of the Moon ARC, Darrel Jones WD6BOR, 707-996-4494

IA - DES MOINES - Hamfest. Des Moines RAA, Duane Bower WB0UCY, 515-287-6542.
E-Mail: duaneab@uswest.net

IL - STICKNEY - Hamfest. Hawthorne Race Course, 3500 S. Cicero Ave. VE Testing. Talk-in: 145.25. DuPage ARC, 630-985-9256.
E-Mail: DARChamfest@aol.com
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SC - SPARTANBURG - Hamfest. County Fairgrounds, 275 W. Bishop St. 8am-3pm. Blue Ridge ARS, Inc., Robert G. Watson W4RGW,
E-Mail: w4rgw@arrl.net

APRIL 30

DE - NEW CASTLE - State Convention. Nur Temple, Rt. 13. 8am-1pm. VE testing. Talk-in: 146.955- or 224.220/R. Penn-Del ARC, Hal Frantz KA3TWG, 302-793-1080.
E-Mail: hfrantz@snip.net
Web: http://www.magpage.com/penndel

IL - ARTHUR - Hamfest. Moultrie/Douglas County Fairgrounds. 8am-1pm. Talk-in: 146.055/146.655 & 449.275/444.275. Moultrie ARK, Ralph Zancha WC9V, 217-543-2178 days and 217-873-5287 eves.
E-Mail: rzancha@one-eleven.net

IL - GALVA - Hamfest. Area Amateur Radio Operators, Bill Anderson WA9BA, 309-932-3023.
E-Mail: bill@inw.net
Web: http://www.qsl.net/aaro/index.html

OH - ATHENS - Hamfest. Athens County ARA, John Cornwell NC8V, 740-593-6474.
E-Mail: jcornwell@eurekanet.com

PA - WASHINGTON - Hamfest. WACOM, Dave DeMotte N3IDH, 724-228-8178.
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MAY 5-6

LA - BATON ROUGE - State Convention. Baker Civic Auditorium, 3325 Groom Rd. VE Testing. Baton Rouge ARC, Herb Ramey W5LSU, 225-654-6087. E-Mail: W5GIX@AOL.COM
Web: http://www.brarc.org

MAY 6

AR - SILOAM SPRINGS - Hamfest. St. Mary's Catholic Church, 1996 Hwy. 412 E. 8am-3pm. Talk-in: 146.67. Siloam Springs ARC, Matt Hyde N5UYK, 501-524-4797

AZ - SIERRA VISTA - Hamfest. Cochise ARA, Raymond Berger W1LYT, 520-378-4214

CO - MONUMENT - Hamfest. Pikes Peak RAA, Robert Ryals KI0GF, 719-265-9950.
E-Mail: rryals@pcisys.net
Web: http://www.qsl.net/ppraa/swapfest.htm

MI - CADILLAC - Hamfest. Wexaukee ARC, Alton McConnell NU8L, 231-862-3774.
E-Mail: amcconnell3@hotmail.com

WI - CEDARBURG - Hamfest. Ozaukee RC, Joe Holly AA9HR, 262-377-2137; E-Mail: aa9hr@execpc.com. Skip Douglas, 262-284-3271

MAY 6-7

AL - BIRMINGHAM - Hamfest. Glenn Glass KE4YZK, 205-681-5019.
E-Mail: ke4yzk@bellsouth.net Web: http://www.bro.net/barc/slideshow/index.html

NJ - EDISON - Trenton Computer Festival. NJ Convention & Exposition Center, Raritan Center. KGP Productions, Inc., 1-800-631-0062.
E-Mail: kgp@mail.com Web: http://pcshow.com

TX - ABILENE - Hamfest. Abilene Civic Center. Sat: 8am-5pm, Sun: 9am-2pm. VE Tesing. Talk-in: 146.160/760. The Key City ARC, Peg Richard KA4UPA, 915-672-8889. E-Mail: ka4upa@arrl.net

MAY 7

MD - HAGERSTOWN - Hamfest. Hagerstown Community College Recreation Center. VE Testing. Talk-in: 146.94 & 147.09. Antietam RA, Inc., Tina Jones KB8ZQM, 304-728-7769.
E-Mail: kb8zqm@intrepid.net
Web: http://www.qsl.net/w3cwc

NY - YONKERS - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053.
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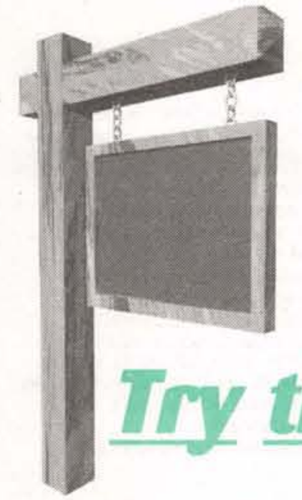

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110. Cable TV
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130. Antique Electronics
135. Aviation Electronics
140. Publications
145. Robotics
150. Plans/Kits/Schematics
155. Manuals/Schematics Wanted
160. Misc. Electronics For Sale
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175. BBS & Online Services
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190. Business Opportunities
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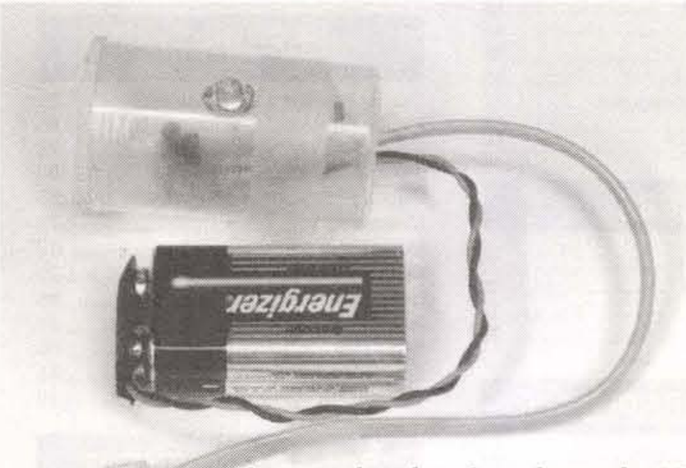
ADVERTISER INDEX

Find what you need FAST by Product or Category

by Fred Blechman

Build a Telephone-Busy Lite

Plug this simple project into your phone line and when any phone using that line is in use, the red LED will light. Using only seven working parts, you can build this from scratch, or from a $9.95 complete kit that includes a printed circuit board and modular telephone connector.



The completed project shows the LED sticking up through the 35mm container for easy visibility. Simply plug into the telephone line and it's ready to operate.

You're happily reading your E-Mail or are in a chat room when suddenly a bunch of gibberish appears on the screen. You're on the Internet, checking in with your favorite newsgroup or scanning a neat web site, when the screen freezes and you are dumped off the Internet.

Computer problem? Software problem? Windows crash? Bad modem? Internet service provider (ISP) problem? Telephone problem? Could be a lot of things, but the most likely cause is that someone picked up an extension telephone on the line your computer modem was using!

If the telephone line you use for your computer modem has extension telephones on that same line, you are playing "Modem Roulette" whenever you are on-line. While it won't always cause your modem to get confused when people dial a number or start talking on an extension, it usually will cause some sort of anomaly. Solution: Have a "telephone-busy" warning light at all your extensions. When you're using that line on the computer, the "busy" lights will be on. Also, if you have a busy-light at your computer, you'll know the phone line is not available when the light is on.

The "Tel-Lite-1 Phone Busy Light," which you can build from scratch or from a $9.95 kit, is a high-impedance device that directly connects to the phone line without interfering in any way with telephone use. It only has seven working parts, so it's easy to put together — if you can find the three parts that are somewhat unique. More on that later.

The Circuit

Figure 1 shows the schematic diagram for Tel-Lite-1. You'll notice immediately that three "unusual" semiconductors are specified: Q1, a 2N7008 N-Channel MOSFET; Q2, an MPSA 14 NPN Darlington transistor; and D2, a 5.6 volt zener diode.

To understand how this circuit functions, you'll need some understanding of a typical phone system, and how MOSFETS, Darlington transistors, and zener diodes work. Also, we will assume "current flow" is from positive to less-positive, or ground return.

To begin with, although it is not general knowledge, a typical phone circuit, except when it is ringing with an AC (alternating current) signal, operates on DC (direct current). When all phones on a line are "on-hook" (hung up), about 40 volts DC appears across two telephone wires — usually red and green, with the green more positive. (Yeah, I know. You would expect the red to be the positive. It isn't!)

When *any* of the phones on that phone line are "off-hook" (being used), the voltage drops to about five volts DC. Note that the values of 40 volts on-hook and five volts off-hook are variable, depending on several conditions. The important point here is that there is a very significant drop in DC voltage when any phone instrument on that line is in use.

Now, how about Q1? This is an N-channel MOSFET, a Metal-Oxide Silicon Field Effect Transistor, shown schematically in Figure 2. It has such high input resistance at the gate that it essentially is a voltage-sensing device. It takes only a small voltage at the gate to allow current to flow from the positive drain through the source to ground.

Q2, the Darlington transistor (Figure 3), is merely two NPN transistors internally connected together in a "Darlington pair," which multiplies the gain of each. It is, essentially, a very high-gain transistor, taking very little current input at the base (B) to allow large current flow from the positive collector (C) through the emitter (E) to ground.

The zener diode is a special diode that resists current flow from anode to cathode below its rated voltage. Above this voltage, it allows current to flow while it maintains essentially the rated voltage drop. (Purists Note: These explanations are simplified, but sufficient to explain the operation of this circuit.)

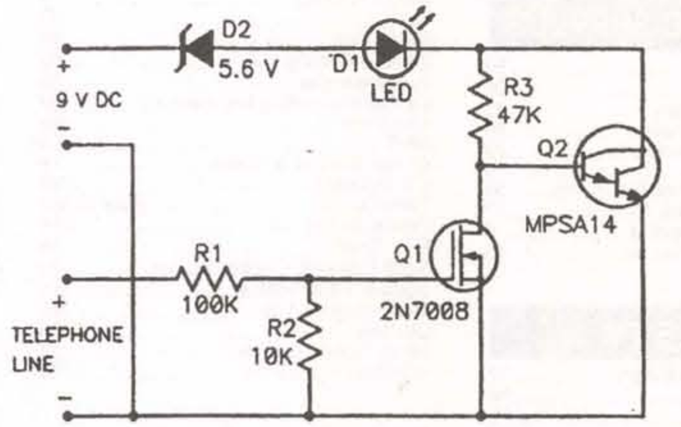


Figure 1 — Tel-Lite-1 Schematic

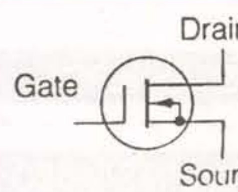


Figure 2 — N-Channel MOSFET Schematic Symbol

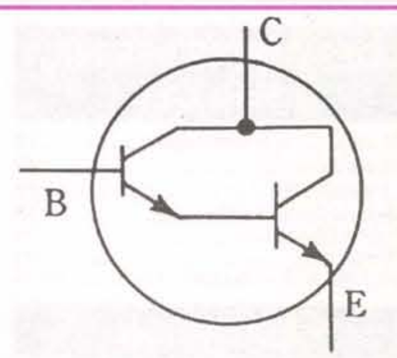


Figure 3 — NPN Darlington Transistor Schematic Symbol

Circuit Operation

Looking again at Figure 1,

assume for the moment that the Tel-Lite-1 is plugged into the telephone circuit, and all phones are on-hook. The telephone line voltage is approximately 40 volts DC. Resistors R1 and R2 form a voltage divider, so the voltage at their intersection is 10K/(100K+10K) or 10/110=.09 times the telephone line voltage, or about 3.6 volts. This is more than enough voltage at the gate of Q1 to force Q1 into full conduction, essentially placing the base of Q2 at "ground" – the common negative side of both the phone line and the external 9VDC.

With Q2's base essentially "grounded," Q2 has little or no base current, so little or no current flows from collector to emitter. The LED (light-emitting diode) may light very dimly if enough current flows through the zener diode, through the LED, and through Q2 to ground.

But if anyone picks up a telephone on that line, the line voltage drops to about five volts, and the voltage at the gate of Q1 drops to about .45 volts. This is not enough to allow Q1 to conduct, so it releases the base of Q2 from being grounded.

Q2 now has a sufficient positive bias on its base through R3 to go into conduction, and the LED now sees a low-resistance path through Q2 to ground – so it lights brightly! Resistor R3 limits the Q2 base current, thus keeping the current through Q2 from exceeding the LED current rating.

Because only the very high resistance of R1, R2, and Q1 is across the phone line, essentially no current is drawn from the phone line, and there is no effect on phone service.

Kit or Scratch-Build?

Finding some of the parts to build the Tel-Lite-1 from scratch might be a problem. Although other zeners, MOSFETS, and Darlington transistors might be used as substitutes for those identified in the Parts List, it could take some cut-and-try to make things work properly.

Q1 and Q2 are not commonly found in smaller supplier catalogs, and the "majors" usually have a minimum order of $20.00 or more.

Add postage and shipping, possibly from more than one place to get all the parts, and you might be far better off getting the kit, which includes an etched and drilled printed circuit board, and a short phone lead with a modular plug attached, making assembly very easy.

On the other hand, if you have a well-stocked junk-box, and love to experiment, this is an ideal project.

Construction

Figure 4 shows the printed circuit board layout that can be used for this project. If you are building from scratch, a perforated board can be used, connecting the leads following the schematic.

Figure 5 shows the Q1 and Q2 lead designations. Refer back to Figures 2 and 3 for the schematic symbols of Q1 and Q2.

If you use the printed circuit board layout, Figure 6 shows the parts layout. Although there are only seven working parts involved in building this kit, you need to be particularly careful about the proper orientation of D1, D2, Q1, and Q2, and the polarity of the nine-volt battery snap and telephone line cord wires.

For reasons that will be explained later (testing and packaging), leave the LED leads long.

Testing and Using

Once assembled,

Figure 4 – Printed Circuit Board Layout

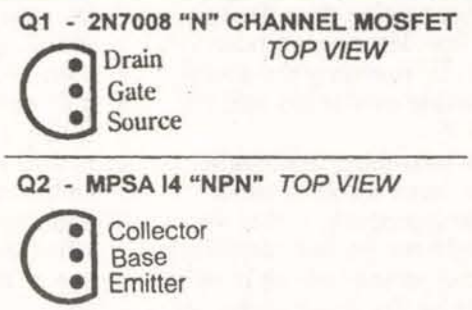


Figure 5 – Q1 and Q2 Pin Designations

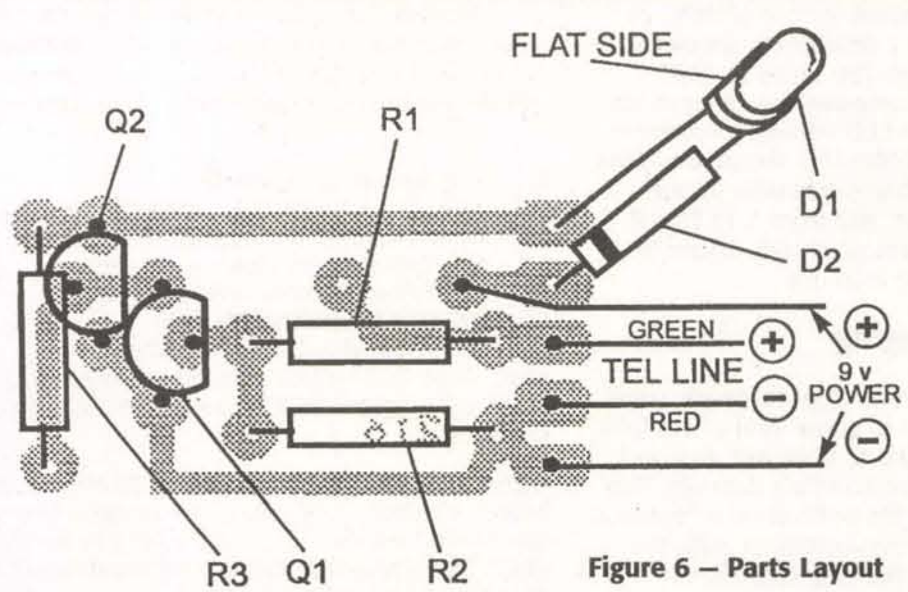
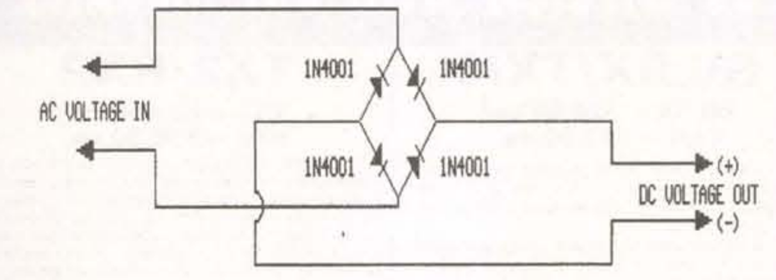
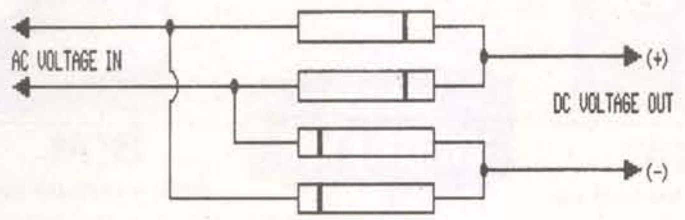


Figure 6 – Parts Layout

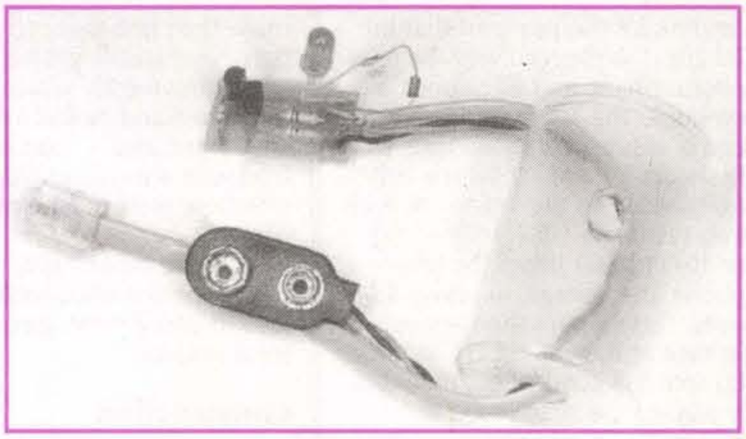


(A) Schematic



(B) Wiring Diagram

Figure 7 — Full-wave bridge rectifier.



The entire unit can be enclosed in a conventional 35mm film container. Note the hole in the container for the LED.

simply plug a standard nine-volt battery into the battery snap without the telephone line connected. The LED should light brightly. If it doesn't, check the proper orientation of D1, D2, Q1, Q2, and the polarity of the nine-volt battery connection.

Next, plug the modular connector into a telephone line, with all phones on that line hung up. The LED should go out, or glow very dimly. If the LED stays bright, check the telephone line polarity.

The final test is simple enough: Take any phone instrument on that line off-hook, and the LED should light brightly.

Note that the Tel-Lite-1 modular connector must be plugged directly to a phone line modular jack, or an extension cord from such a jack. Typically, this involves using a duplex connector, which allows two modular plugs to connect to a single modular jack.

Troubleshooting

If you plug the Tel-Lite-1 into a phone line jack and the LED does not dim considerably, or go out entirely, you probably have reversed polarity at the jack. This is not uncommon.

This comes about if the original phone installation got the wires crossed, or if an extension telephone line cord was improperly wired. Also, some line connectors reverse polarity!

This all stems from the fact that a properly-made telephone line cord with male plugs at each end has opposite wiring at each end! This also applies to a coupler with two female jacks. I've had some cords and couplers that ignored this convention, with the result that some devices that are polarity sensitive — such the Tel-Lite-1 — will not work!

The simplest solution is to unsolder and reverse the line cord leads into the Tel-Lite-1. Another solution is to use a telephone line tester (such as the RadioShack 43-104) and plug it into the jack that you intend to plug the Tel-Lite-1 into. A green light on the tester indicates proper polarity (green positive); a red light means the polarity is reversed.

Along with this confusion, you should know that Tel-Lite-1 will probably not work properly if you try to connect it at the telephone instrument rather than the telephone line. Here again, however, you can try reversing the green and red line cord leads into the Tel-Lite-1.

The next thing that might happen, even if you've wired everything properly, is that the LED might not go out completely when the phones are all hung up. This can be the result of the very high gain of the Darlington transistor, some internal resistance in the MOSFET, and excess current through the zener diode.

You can overcome this to a large extent (or completely) by putting a resistor (try various values from 220 ohms to 1500 ohms) between the zener diode and the LED. Ideally, the current through the LED should be about .05 milliamperes with phones hung up, and from 5 to 10 milliamperes when any phone on that line is in use.

Packaging

I prefer to package my small projects in some kind of available enclosure to keep out dust and minimize handling damage. This project fits perfectly in a common 35mm film container, with the battery hanging outside.

If you plan to do this, poke a hole in the bottom of the film container using a hot soldering iron tip, and feed the two external wire sets (nine-volt battery connector and phone lead) through the hole *before* soldering the wires to the circuit board.

Once completed and tested, estimate where the LED will be located inside the container and poke another hole for the LED to stick through.

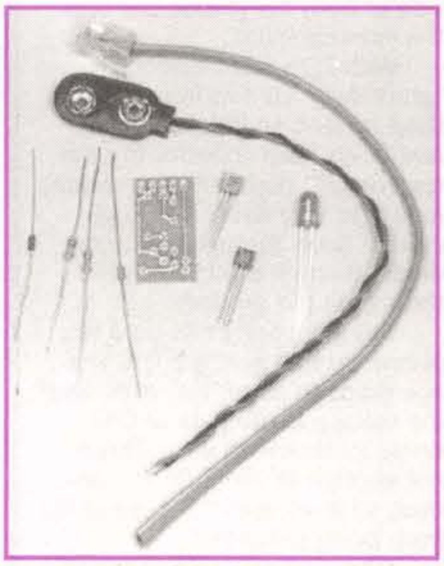
External Power

Since this circuit draws some current from the battery even when all phones are not in use, and a significant current from the battery when any phone on that line is in use, you might want to consider an external power supply to replace the battery.

The most simple way to do this is to use a wall-plug type of DC power supply that provides 9VDC. Since most of these supplies actually provide considerably more than nine volts when under a light load, you may need to add a resistor, as mentioned earlier, between the zener diode and the LED to dim the LED when all phones are on-hook, or use a DC supply with lower voltage.

If you use a multi-voltage unit, you might find a setting lower than nine volts will be adequate to provide sufficient LED light when active.

Another alternative is to use a low-voltage AC adapter (about 6VAC) and a simple full-wave diode bridge circuit made from four common 1N4001 silicon rectifiers, as shown in Figure 7, to rectify the AC to DC. You won't need to use filter capacitors to smooth the current, but you may need a zener diode/LED resistor mentioned earlier to limit LED current to around 5 to 10 milliamperes.



A complete kit of parts includes the printed circuit board, battery connector, and telephone cord with modular connector.

Summary

You can have a lot of fun building and experimenting with this circuit, and end up with a very useful device that can keep you perkin' along on the Internet without someone picking up the phone and crashing your modem connection! **NV**

Parts List

D1 - Red light-emitting diode
D2 - 1N4734 or 1N752 5.6V zener diode
R1 - 100K 1/4-watt 10% carbon resistor
R2 - 10K 1/4-watt 10% carbon resistor
R3 - 47K 1/4-watt 10% carbon resistor
Q1 - 2N7008 N-Channel MOSFET
Q2 - MPSA-14 NPN Darlington transistor
Misc.: Nine-volt battery connector, phone cord with modular plug.
Optional: External 9VDC power, or 6VAC power and four 1N4001 silicon rectifiers.

A complete kit of parts, including an etched and drilled printed circuit board, a battery connector, and modular line cord, is available from: Electronic Rainbow, Inc., 6227 Coffman Road, Indianapolis, IN 46268 (317) 291-7262. Free catalog; www.rainbowkits.com; VISA/MC; $9.95 plus $5.00 S/H. IN residents add 5% sales tax.

by Dennis Eichenberg

COUNTDOWN CONTROLLER

The circuit presented here is an exciting and attention-getting means of providing a graphic time-delayed contact closure. The circuit was designed to be simple, inexpensive, and reliable. The circuit is ideal for toys and appliances where a time delay prior to activation is desired. Applications include toy rocket ignition systems and camera self-timers.

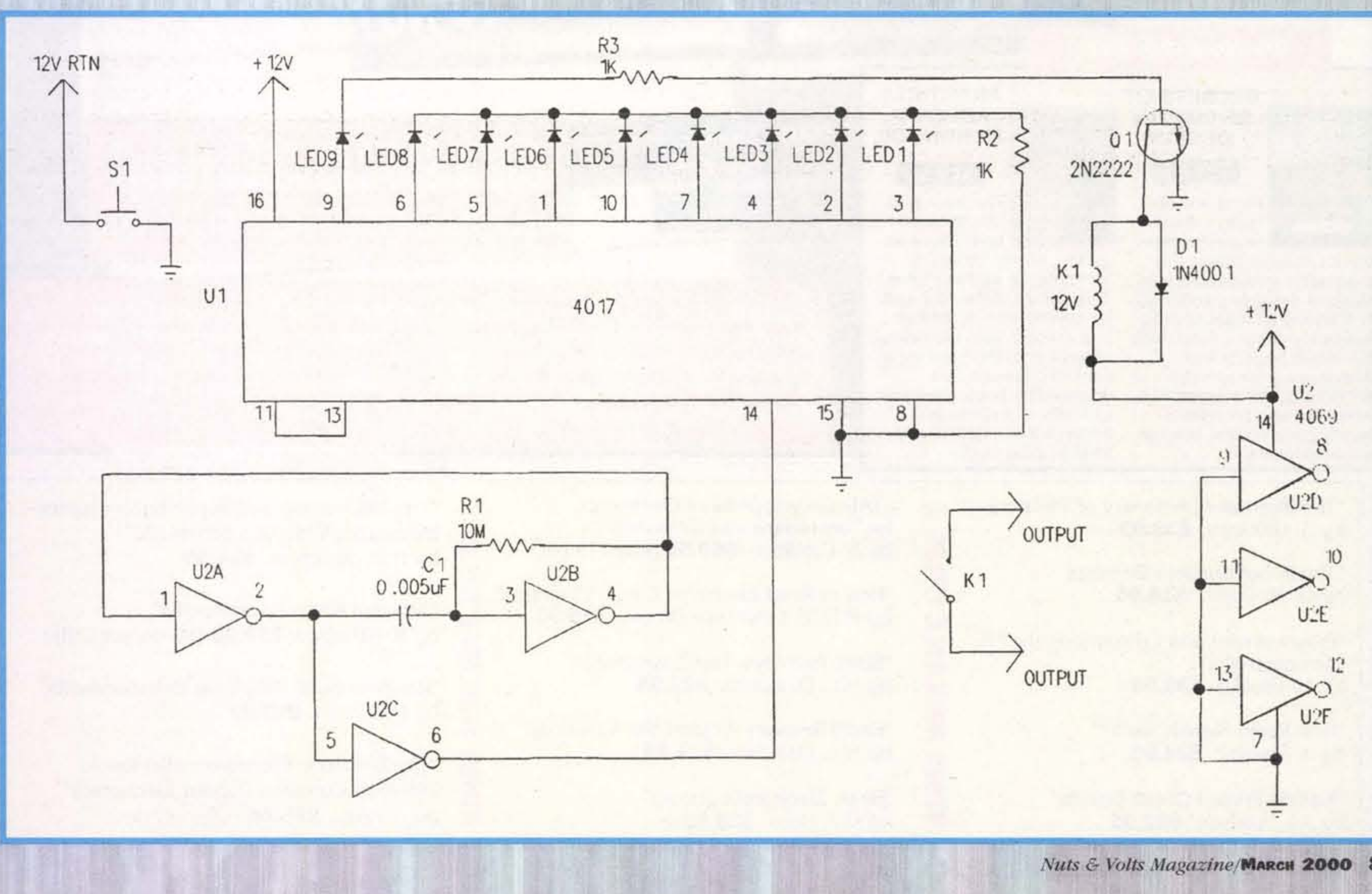
•

Pressing push-button switch S1 starts the LEDs illuminating one at a time from LED1 through LED9. When LED9 illuminates, relay K1 closes momentarily. Releasing S1 in the middle of a sequence causes the sequence to stop, and starts from the beginning when S1 is pressed again.

Pressing S1 provides power to the circuit and resets decade counter U1. Inverters U2A and U2B are configured as a simple astable multivibrator to act as a clock for the circuit. The frequency of the clock is approximately 1/(2.2 x R1 x C1), which is about 9 Hz for the circuit. U2C acts as a buffer for the clock to drive U1. LED1 through LED9 are conventional LEDs. An LED bargraph display is ideal for this application. Resistor R2 is a current limiting resistor for LED1 through LED8. A single current limiting resistor is acceptable since only one LED is illuminated at a time. LED9 drives transistor Q1 via current limiting resistor R3. Q1 energizes relay K1 while LED9 is illuminated. Diode D1 is a flyback diode to protect Q1 from the inductive spike generated by K1 when it is deactivated. Normally open relay contact K1 is used to provide a momentary contact closure. The relay contacts must be sized properly according to the specific application. **NV**

COUNTDOWN CONTROLLER PARTS LIST

No.	Description
U1	Divider, CMOS, 4017B, RadioShack No. 276-2417
U2	Inverter, CMOS, 4069UB, RadioShack No. RSU 11392230
Q1	Transistor, NPN, 2N2222, RadioShack No. RSU 11328499
D1	Diode, 1N4001, RadioShack No. 276-1101
K1	Relay, 12V, RadioShack No. 275-248
S1	Switch, normally open push-button, RadioShack No. 275-1547
LED1-9	LED, red, RadioShack No. 276-041
R1	Resistor, 10M, 1/4 watt, RadioShack No. 271-1365
R2, 3	Resistor, 1K, 1/4 watt, RadioShack No. 271-1321
C1	Capacitor, 0.005 uF, RadioShack No. 272-130



The Computer Controlled World: RS-232 Network Control Methods and Applications

More Byte Bugs

by Ryan Sheldon, National Control Devices • (417) 646-5644 • www.controlanything.com

Nine new CPUs simplify YOUR computer-controlled world.

A couple of months ago, I released the Anabug and Bitabug preprogrammed microcontrollers. Unfortunately, I had to discontinue these parts due to the cost and time involved in producing working samples. My apologies to all of you who have called and E-Mailed. We were only able to distribute a small quantity of these devices.

I now have replacements, and even spent a little time expanding on some ideas. As of February 1st, I have released nine new microprocessors that are easy for us to produce, while meeting my original criteria: Simple to use.

As you can imagine, writing firmware all day long can get a little dull. So to take the boredom out of things, I spent some quality time developing two new CPUs that have absolutely nothing to do with computer control. VU Meter and VU Meter2 are the first in my series of Analog Control Processors — CPUs that do a specific function without a computer attached.

I will discuss these chips in greater detail at the end of the article. But for now, I want to introduce you to my new family of CPUs that will take the pain out of your computer controlled world.

Due to space limitations, this article will simply serve as an introduction to my new CPUs. A full-blown article could be written about each one, but I would prefer to introduce you to 10 more CPUs next month. Example source code for Visual Basic 6 is now on-line at www.controleverything.com. Click on the "Products" link, then click "Microcontrollers." Download the Bugs.ZIP file for Visual Basic 6 example software for all of these devices.

I'm going to move quickly, so hold on tight. We have a lot of ground to cover and I bet I can get you flying faster and further than anybody. But first, there are a few things about the diagrams that you should know when building these circuits.

Connectors

The connectors shown in these diagrams use a DB9 female with wire connections shown from the solder side of the connector.

Ceramic Resonators

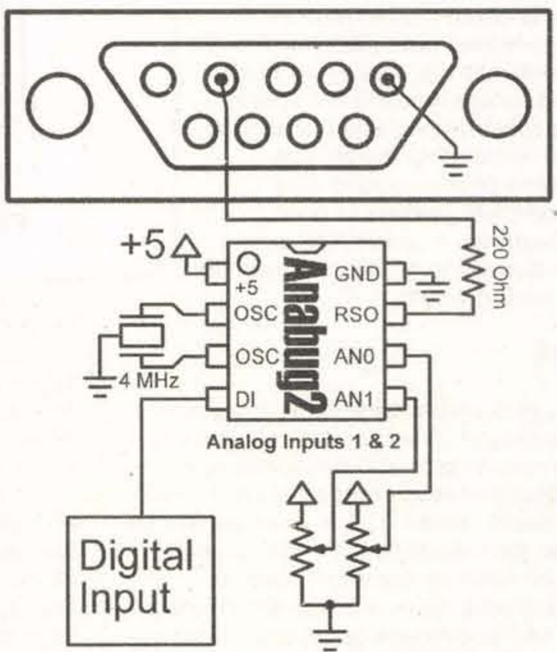
Ceramic resonators are supplied with all preprogrammed microcontrollers. Ceramic resonators are not polarity sensitive. However, the center lead must be connected to ground. Ceramic resonators should always be located as close to the chip as possible.

No Breadboards

Never use a breadboard when building

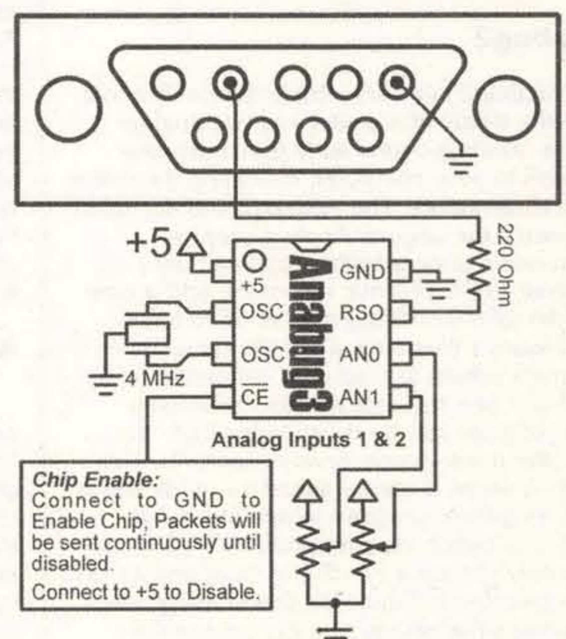
Figure 1: Anabug2 Visual Basic 6 Program

Figure 3: Anabug3 Visual Basic 6 Program



RS-232 Connector: Solder Side of DB-9 Female Shown.

Figure 2: Anabug2 Circuit Diagram



RS-232 Connector: Solder Side of DB-9 Female Shown.

Figure 4: Anabug3 Circuit Diagram

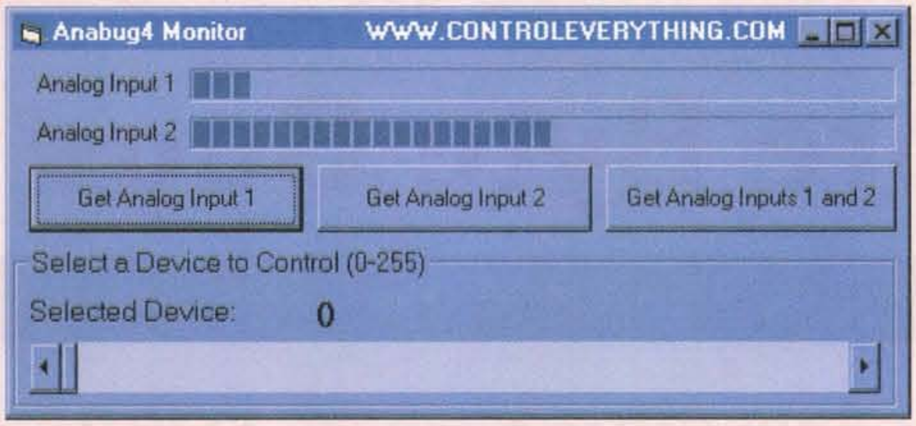


Figure 5: Anabug4 Visual Basic 6 Program

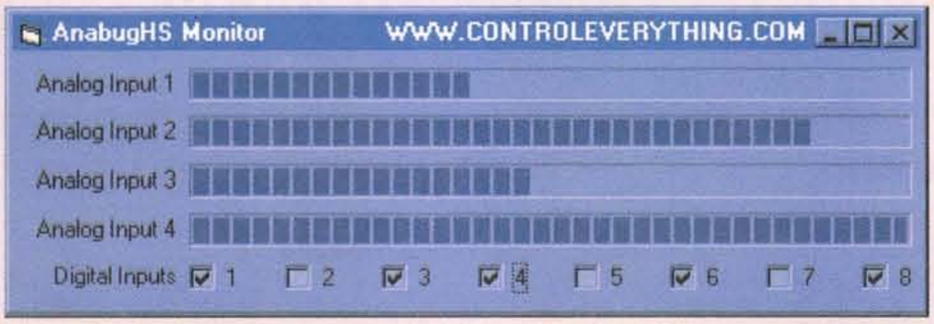


Figure 7: AnabugXT Visual Basic 6 Program

Figure 8: AnabugHS Visual Basic 6 Program

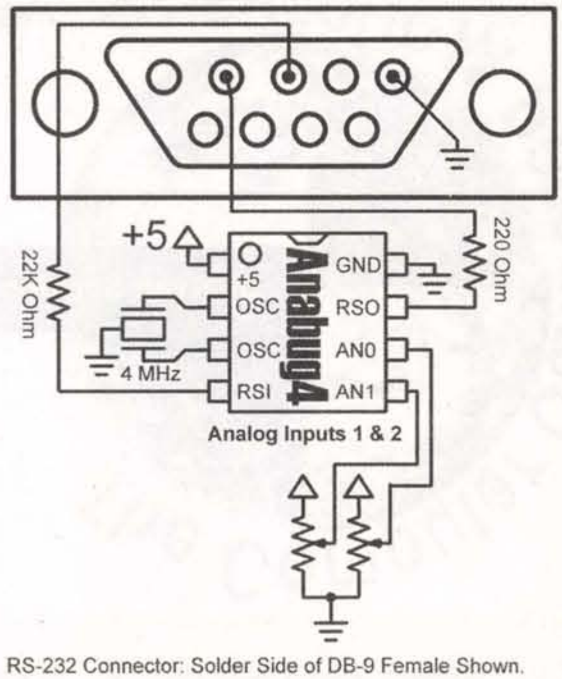


Figure 6: Anabug4 Circuit Diagram

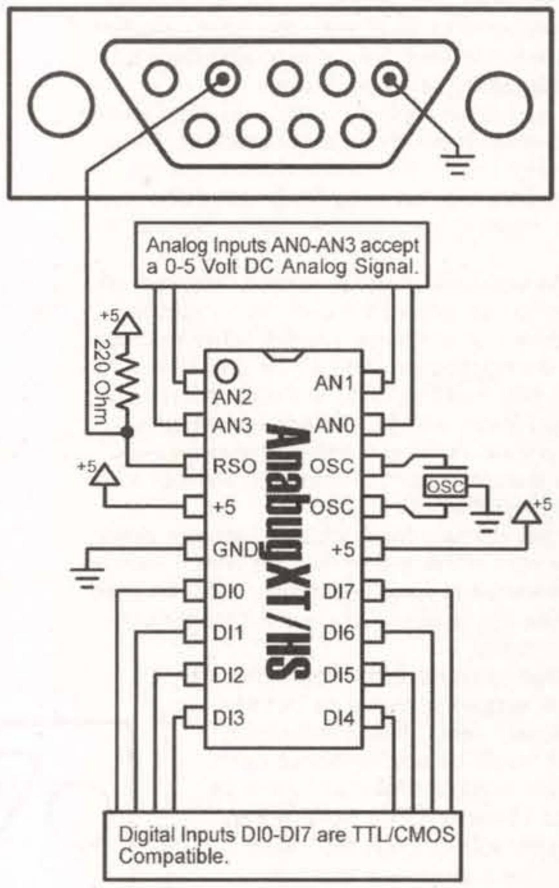


Figure 9: AnabugXT/HS Circuit Diagram

any of these circuits. Breadboards have been known to cause device failure with many PIC microcontrollers. Most breadboards are capacitive, which has been known to disrupt or permanently damage the oscillator driver on PIC devices. For best results, use a solder-based prototyping method.

Anabug2

Anabug2 is a very simple device that monitors the status of a digital and two analog inputs. Anabug2 constantly transmits data packets to your computer, indicating the status of all three inputs. The Anabug2 was designed to replace the original Anabug preprogrammed microcontroller. Anabug2 uses an external 4-MHz ceramic resonator, and is now capable of transmitting data at 9600 baud.

Figure 1 illustrates a simple Visual Basic 6 program written to read data generated by the Anabug2 preprogrammed microcontroller. This program can be downloaded from my web site at www.controleverything.com. The Anabug series is ideally suited for applications such as general-purpose temperature, light level, and switch closure monitoring. Because they only require a handful of components (as demonstrated in Figure 2), the Anabug series is perhaps the easiest way to communicate real-world data to a desktop PC.

Anabug3

Anabug3 was designed because one of our users needed a way to easily enable and disable data packet transmissions. Anabug3 has two analog inputs and a chip enable line. When the chip enable line is connected to ground, Anabug3 generates data packets. When the chip enable line is connected to +5, the Anabug3 stops sending data packets. Data packet transmission cannot be interrupted by the chip enable line, which ensures your computer only receives complete packets of data. Figure 6 illustrates a simple VB6 program for adjusting level meters based on incoming analog values.

Anabug4

Anabug4 is perhaps the most sophisticated of our eight-pin Byte Bug A/D converters. You can connect up to 256 Anabug4s to a single serial port and read analog data from each chip individually. That's 512 A/D inputs from a single serial port. Anabug4 is a polled device and relies on two-way communication to receive commands from a computer. Anabug4 has three A/D conversion commands used to read the status of A/D input 1, input 2, or both inputs simultaneously as shown in Figure 6.

The Anabug4 program has a slider used to select which device you are speaking to. Anabug4 supports the full E3C command set, allowing 256 E3C compliant devices to share a single serial port in any combination.

It is possible to chain several Anabug4s on a single serial port by simply connecting all the data inputs to the RS-232 data output, and all the data outputs from the Anabug4 to the RS-232 data input. A device number is burned into the chip at the time of purchase, allowing you to easily specify which device you are

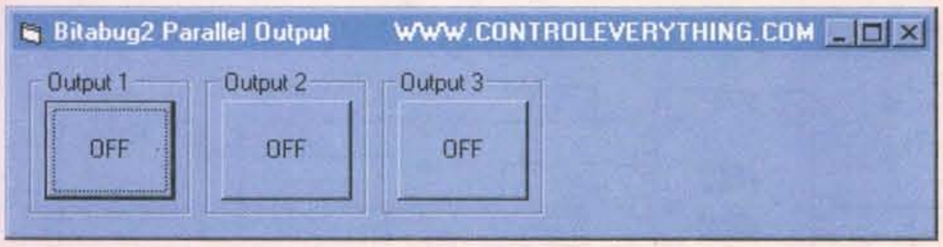


Figure 10: Bitabug2 Visual Basic 6 Program

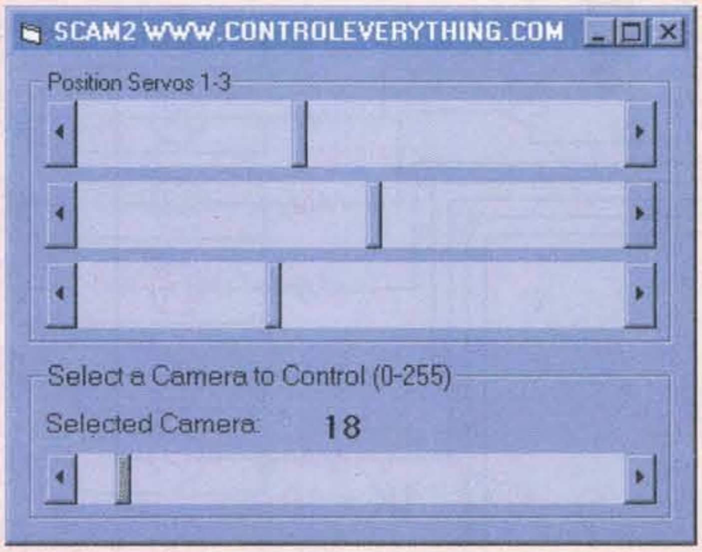


Figure 12: SCAM2 Visual Basic 6 Program

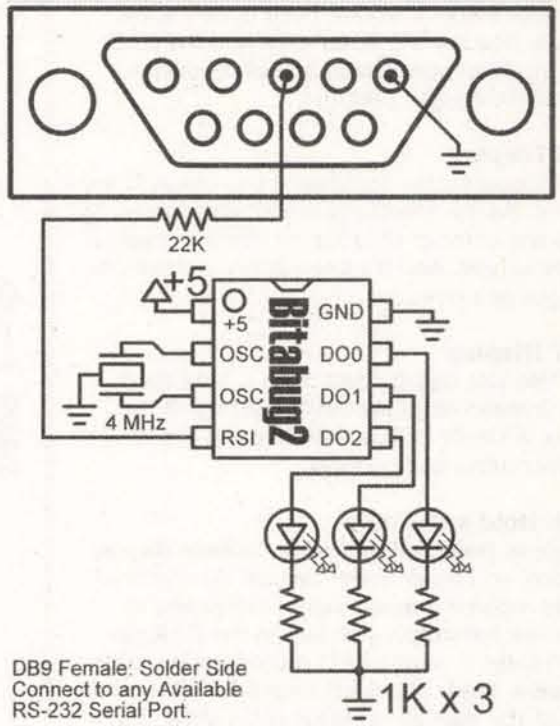


Figure 11: Bitabug2 Circuit Diagram

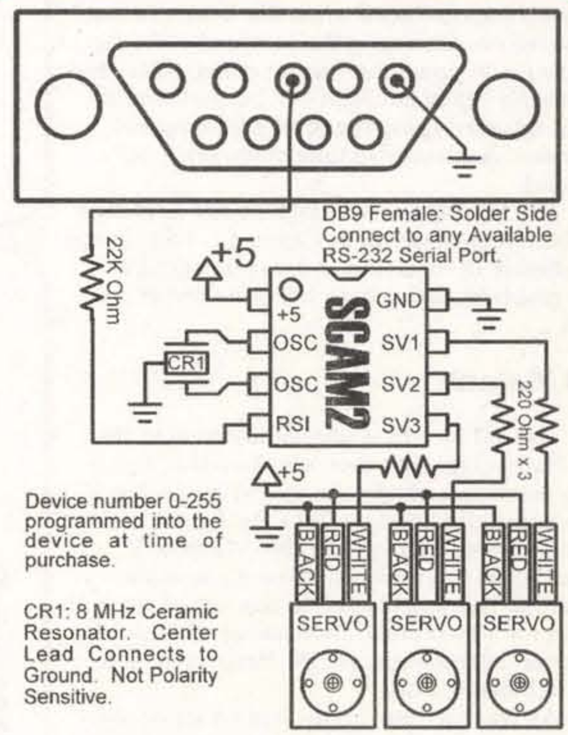


Figure 13: SCAM2 Circuit Diagram

speaking to.

AnabugXT/HS

AnabugXT/HS was designed to provide users with a simple way of reading eight digital inputs and four analog inputs into a computer. If you ever wanted to build your own joystick, the AnabugXT is a perfect choice for monitoring up to four potentiometers and eight buttons. AnabugXT sends seven-byte packets of data to your computer at 9600 baud. If you need high-speed communication, AnabugHS is capable of sending data at 38.4K baud to your computer.

There is very little difference between the programs for AnabugXT and AnabugHS. Other than the label name and a baud rate change in the Visual Basic 6 source code, these programs are identical. One note worth mentioning — at 38.4K baud, the AnabugHS is very responsive and is perfect for applications where you might want to monitor time-critical tasks.

AnabugXT is supplied with a 4-MHz ceramic resonator, capable of generating seven-byte data packets at 9600 baud. AnabugXT can be over-clocked to 8 MHz for data transmission at 19.2K baud. AnabugHS is supplied with a 16-MHz ceramic resonator, capable of generating data packets at 38.4K baud. AnabugHS can be clocked up to 20 MHz, which generates data packets at 40K baud. Unfortunately, this baud rate is not supported by Visual Basic 6.

Bitabug2

Bitabug2 is a no-frills, three-bit serial-to-parallel converter that only responds to ASCII character codes 0-7. Bitabug2 was designed to replace the original Bitabug preprogrammed microcontroller. Figure 10 illustrates a simple program that can be used for controlling each individual output.

SCAM2

If you remember last month's article, "The SCAM Chip," then you saw how the SCAM chip could be used to control the position of two servo motors and the on/off status of a relay using only a few lines of code. The SCAM2 is very similar to the original SCAM chip. Instead of having a relay output, the SCAM2 is capable of driving a third servo motor.

Both the SCAM and the SCAM2 chips are E3C compliant, allowing up to 256 devices to share a single serial port. An 8-MHz ceramic resonator is supplied with the SCAM and SCAM2 chips. Figure 12 illustrates a simple program for controlling the position of three servo motors on 256 different devices. Note that it may be necessary to duplicate the transmission of commands to the SCAM chip. Please download our complete data sheet for details.

My Vacation

My idea of a vacation is writing firmware that has nothing at all to do with computers. I hope to work on a lot of applications like this in the coming years; they have been a lot of fun and give me a much needed break from the same old routine (no pun intended).

When I was a kid, I bought a few of the LM3914s when experimenting with building an LED VU level meter. They were pretty cool ... for the time. But I always wanted something a little flashier. While I am sure it exists out there somewhere, I have not yet found it, so I decided to write a couple of my own LED VU meter programs. They are much flashier than the LM3914 ever was, but more importantly, they do exactly what I want them to do, exactly the way I want them to do it.

VU Meter

You've seen VU Meters adorning the panels of stereos for years. These displays come in all shapes and sizes, but what do they all have in common? They look cool. And that's about it. Some people attach a meaning to these LEDs, but let's face it. They look cool. If it's a coolness race, then I think I may have won that race ... but maybe I'm just partial. If it isn't the coolest one out there, it has to be one of the cleverest. After all, I am driving 20 LEDs with only 11 pins of PIC, that's got to count for something. Right? Bank switching is nothing new, but it's my first attempt and I think it

turned out all right.

Here's how it works: Feed in two audio signals into the VU Meter chip and the LED bar graph responds with one of three user-selectable display patterns.

BAR Display

Of course, the traditional bar graph is supported. As the incoming audio signal rises, so does the number of LEDs on the bar graph. Pretty simple, and it's been done to death. So I've got one now, too.

DOT Display

The Dot display pattern is a little more rare. Instead of sequentially lighting all the LEDs, a single LED is lit indicating the level of the incoming audio signal.

Peak Hold and Fall

Peak Hold and Fall is my favorite display pattern, so I made it the default. As the level of the incoming audio signal increases, so does the bar graph, just like in the BAR display mode. A single LED momentarily holds the peak level. This LED then falls off the bottom of the display unless it is "Pushed" back up by the incoming signal. Definitely a premium display pattern.

Note that these display modes are user selectable using jumpers J1 and J2. The display settings are read when the device is first powered on. Changing the jumpers while the display is in operation has no effect. Also, the incoming signal strength can be mathematically adjusted using the level adjust potentiometer. Adjustments take place once per second.

The VU Meter chip can be used as shown in the circuit diagram in Figure 14. This device is capable of receiving and displaying LED bar graph levels for both left and right channels.

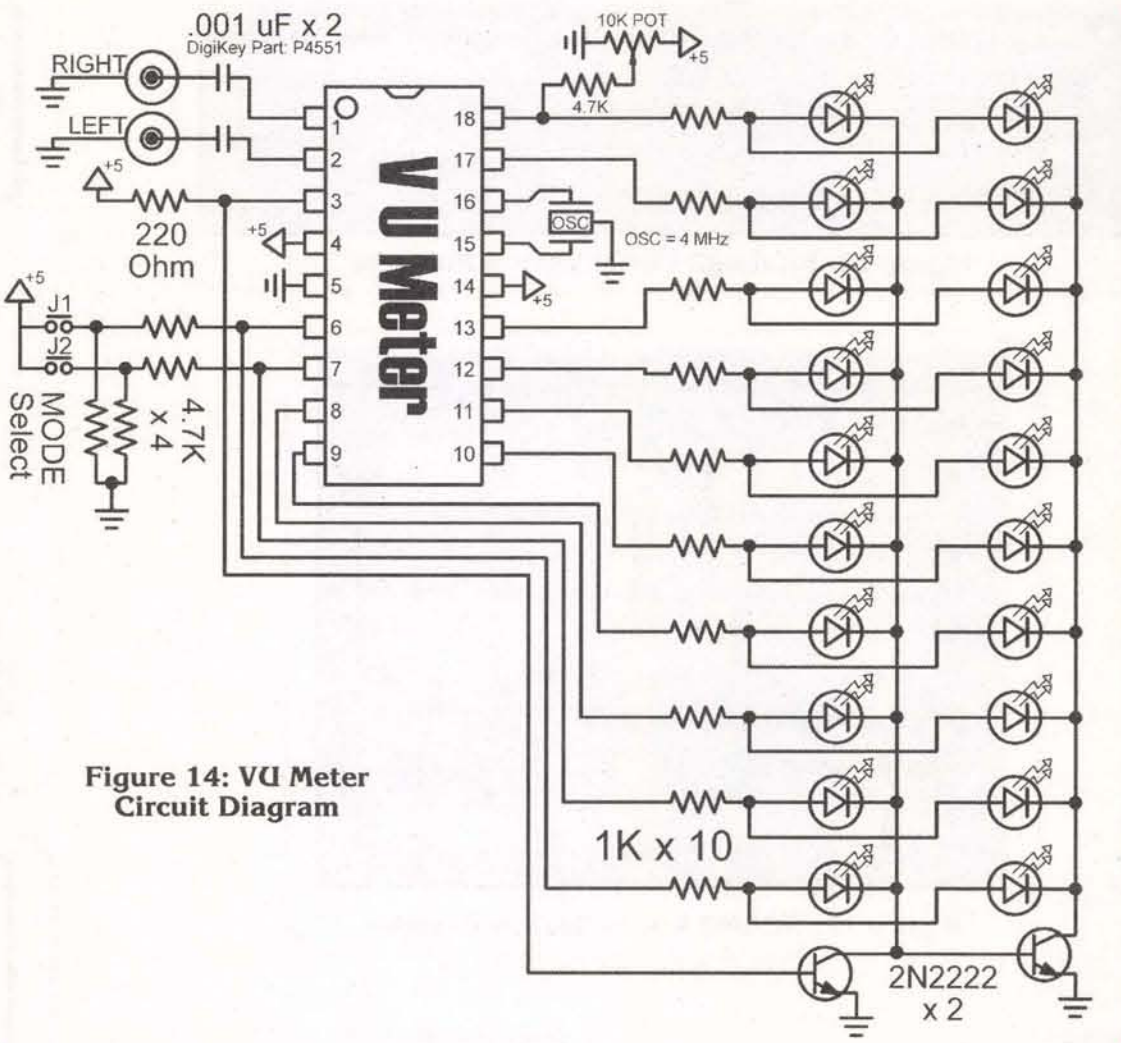


Figure 14: VU Meter Circuit Diagram

VU Meter2

The VU Meter2 is almost identical to the VU Meter chip, with the exception that it can only listen to a single channel of audio, but it can output the level to 20 LEDs. So the resolution is twice as high with the VU Meter2 chip, but at the sacrifice of an audio input channel. You would need to use two of these chips for stereo audio monitoring. Electrically, you can interchange the VU Meter chip with the VU Meter2 chip.

As you can see, I have done a lot of playing this past month. I hope you have enjoyed reading about some of my more interesting projects and I hope you enjoyed this month's "Computer-Controlled World." Please feel free to call or send me an E-Mail if you have any questions. **NV**

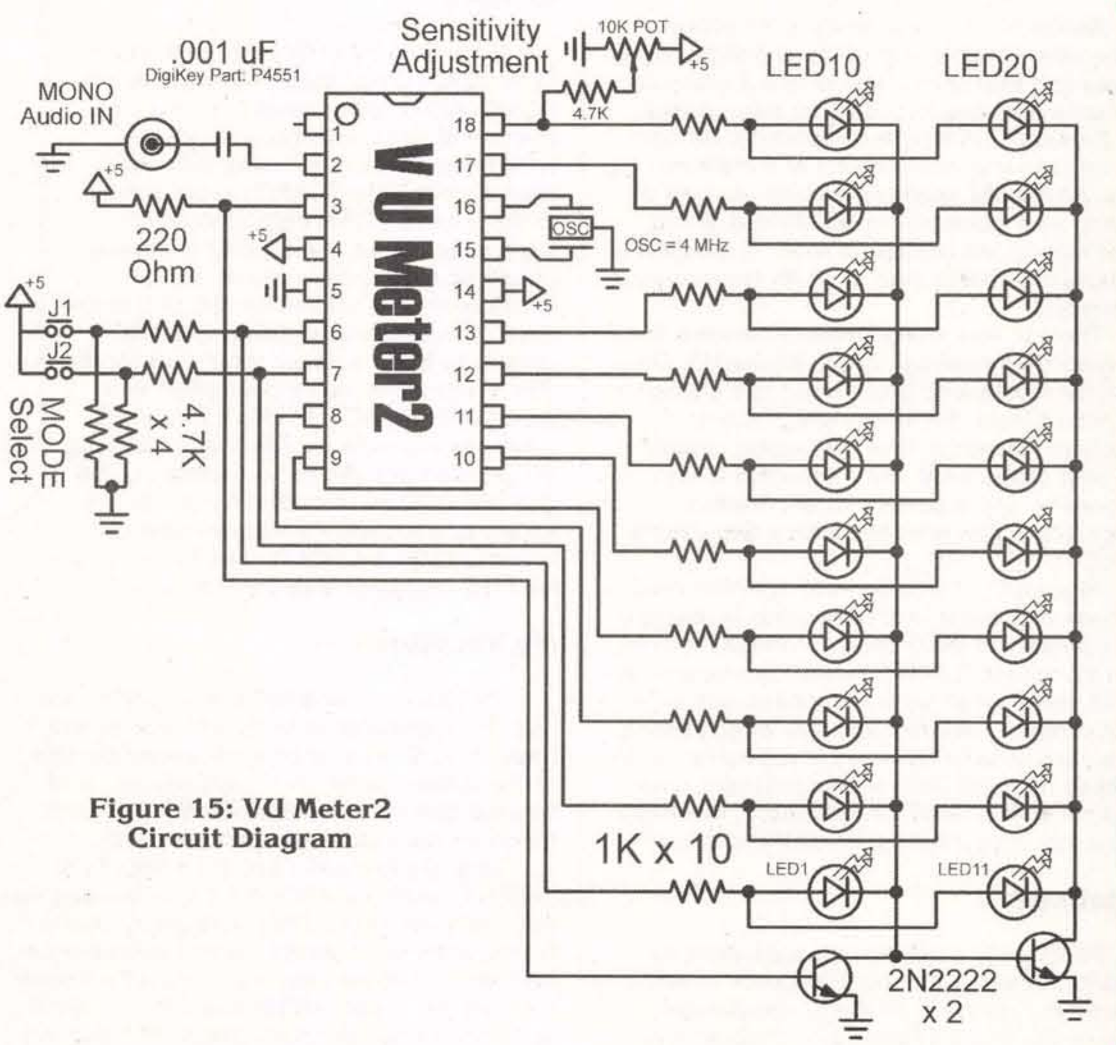


Figure 15: VU Meter2 Circuit Diagram

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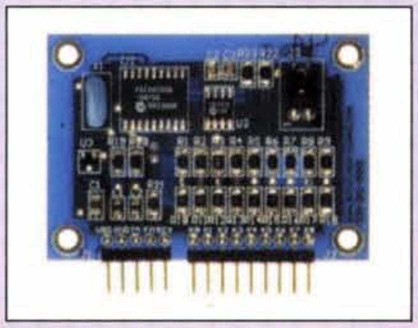
New Product News

MEMKEY KEYPAD ENCODER



The MEMKey is a fully programmable keypad encoder. Using a jumper, the MEMKey supports either a simple serial communication protocol or the standard PC/AT communication protocol. In either communication mode, it can decode key matrixes of up to four columns by five rows. The rows and columns can be programmed to match the row-column configuration of any off-the-shelf keypad.

The value returned by the MEMKey can be programmed to any standard value. In addition, the debounce time and typematic rate are fully programmable. All programmable values are stored in non-volatile memory so they are saved when power is off.

When operating with the serial protocol, the MEMKey communicates at 2400 baud, 8N1, LSB first, asynchronous. This can be either a one-wire or two-wire interface.

In addition, there are 64 bytes of EEPROM memory which is made available to the user as scratch pad space.

The MEMKey's small size and connection scheme allow the device to be inserted directly into circuit boards for production runs, or into breadboards for easy prototyping. Complete data sheets and application notes are available at www.solutions-cubed.com.

The MEMKey comes in a 1.6" x 2.25" SIP module, and sells for $36.00 each.

For more information, contact:

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WEB: www.solutions-cubed.com

ASM-4003 2.4 GHz WIRELESS OBSERVATION SYSTEM

Matco releases the ASM-4003 2.4 GHz Wireless Observation System. It features a built-in infrared LED transmitter/camera system with audio for night viewing and a high-performance 5-1/2" B/W monitor/receiver capable of scanning up to three independent cameras up to 400 feet away.

A special 6 dB directional antenna minimizes interference and maximizes picture clarity.

Using the equipped external video jack allows viewing of the transmitted image on any monitor up to 26 inches, either PAL (European Standard) or NTSC video (US Standard).

The system is used as an anti-theft monitoring device for retail stores, an excellent portable baby-observation unit, or an easy plug-and-play warehouse security solution.

An optional universal recessed wall bracket and long-life battery pack is available.

Dealer pricing starts at under $179.00 for a transmitter, camera, monitor, and cable with power adapters.

For more information, contact:

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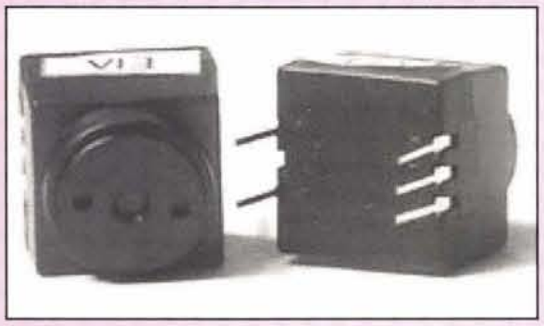

SUGAR CUBE CMOS B/W VIDEO CAMERA

This CMOS-type video camera is specially designed for cost-sensitive consumer electronics applications, and turns a complete video camera into a component of your product.

Features include: small size (16 x 16 x 15mm); pinhole lens; 5V operation with low-power consumption; standard video output; auto exposure control; color correction; and auto gain control.

The camera sells for $49.95, part #99V010.

For technical information, please visit our web site at http://www.alltronics.com.

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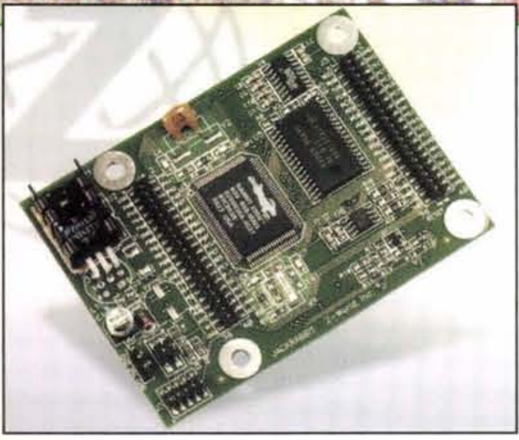

THE JACKRABBIT CONTROLLER

Z-World announces the Jackrabbit™ — a high-performance, single-board computer stocked with I/O, memory, and communication ports.

Priced from only $49.00, the Jackrabbit is loaded with functionality and outperforms all other controllers in its price class.

Features of the Jackrabbit include: C-programmability; 29.5 MHz Rabbit 2000™ microprocessor; 24 general-purpose CMOS level I/O -16 bidirectional, four inputs, and four outputs; four high-power outputs (three sink up to one ampere); two D/A analog outputs and one A/D analog input; two RS-232 ports and one RS-485 port; 5V CMOS port operates at 7.37 bps; five eight-bit timers and one 10-bit timer; 256K flash memory; 128K SRAM memory; on-board watchdog and supervisor; battery-backed SRAM; and battery-backed time/date clock.

Measuring just 2.5" x 3.5", the Jackrabbit is compact, perfect for embedded control.

For more information, contact:

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